# DREDGING HANDBOOK

## A Primer for Dredging in the Coastal Zone of Massachusetts

by Bradley W. Barr, Dredging Coordinator
Massachusetts Coastal Zone Management



Commonwealth of Massachusetts
Michael S. Dukakis, Governor

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**June 1987**

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While every effort has been made to assure accuracy of the information contained herein, any typographical and/or grammatical errors, misstatements of fact, or other deviations from true, plumb, and level are the sole responsibility of the author.

## FORWARD

The Dredging Handbook can be thought of as a kind of nautical chart for those who wish to safely navigate through the straits and shoals of the planning, regulatory, and review aspects of dredging projects. While the act of dredging is simple...the removal of sediment from the bottom of waterways...the scientific, engineering, and regulatory aspects of the process are not.

Because this is an active area of research and investigation, new dredging techniques are being developed, and our understanding of the environmental effects of dredging and dredged material disposal is improving, new and important information is becoming available on a daily basis. Regulations and policies relevant to dredging are also rapidly changing, hopefully for the better, in response to increased information, more reliable predictions of potential environmental impacts, and the availability of a wider array of appropriate mitigation techniques. In response to this change, we intend to update the document (the reason for the three holes in the left margin) on a regular basis, to provide the latest relevant information, to discuss in greater detail specific dredging-related topics of particular concern, and to assure that the most recent regulatory changes are made available to the "dredging community".

To this end, if you wish your name to be placed on a mailing list to receive future updates of the Handbook, please fill out the form below and mail to "Dredging Handbook Update Listing", Massachusetts Coastal Zone Management, 100 Cambridge Street, Boston, Massachusetts 02202. This form, or a reasonable facsimile thereof, must be submitted to ensure that your name or organization is placed on the update list (no telephone messages, please).

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# DREDGING HANDBOOK

## INTRODUCTION

What follows is everything you ever wanted to know about dredging but...as the saying goes...were afraid to ask. This trepidation when it comes to dredging projects is not without some justification. Compared with other coastal projects, dredging requires the collection of very specific (and sometimes costly) scientific information, involves special equipment which may have to be brought in from a great distance, regularly demands that the project be completed in a very specific and limited time period, and requires a significant amount of money just to get the project through the permitting process. The latter can be, for both the project proponent and the regulator a cumbersome, frustrating and sometimes confusing task. No reasonable person initiates a dredging project without good cause.

However, while it may be all these things, it is also necessary. Dredging is vital to those whose livelihood is dependent on being able to get from the pier to the open ocean. The fishery in its many forms, shipping interests and supporting maritime industries all require that ports and navigation channels be kept open and properly maintained. Recreational boating and the marinas, yacht clubs and public facilities which support it are also directly dependent on dredging. In a more indirect way, the public and private beaches which provide recreational opportunities and help protect adjacent structures from storm damage are dependent on the dredged material used to nourish them. There are, without question, many good reasons for dredging projects to be undertaken.

Recognizing this necessity, why is there not a more uncomplicated and straightforward approach to the regulatory framework surrounding such projects? The main reason for the complexity lies in the potential for significant environmental impact. Dredging, in most cases, involves removing sediment, whether silt, sand or gravel, from a physical, chemical and biological system in equilibrium. This sediment is also home, food and protection to a wide variety of organisms which may be commercially important themselves or food for such harvestable resources. Because this system is highly dynamic and complex, our scientific understanding of it is incomplete. This significantly limits not only our ability to predict how the system will respond to a disturbance such as dredging, but may, at a more basic level, severely restrict our ability to even determine, with any degree of certainty, whether "impacts" observed are directly related to the dredging or are a product of natural variability within the system.

Because the potential exists for significant negative and irreversible impact, regulators have chosen to take a highly conservative approach where dredging is concerned. This approach demands that specific and sufficient information be supplied to permitting agencies which deal with dredging projects.

Therein lies the purpose of this review of dredging and dredged material disposal. Knowing what information must be supplied with

applications, which permits are required, and which environmental questions must be addressed are all vital to project success. Knowing when to throw in the towel can be equally as important. Among topics to be discussed are:

- which are the relevant federal, State and local agencies; who gets which application when

- description of dredge types; appropriate uses and limitations

- potential environmental impacts of dredging and disposal of dredged material

- environmental testing requirements; which tests are necessary, how they are done and what the results mean

- disposal options; current state-of-the-art

- paying for it...available funding

- project planning; what to look for in a good design

- where to go for additional information

While no document can answer every question that might possibly arise regarding the subject of dredging, an attempt has been made to cover as much information as possible relating to the regulatory process surrounding this unique activity. Each project is somewhat different depending on the resources that must be considered, the mode of dredging used, the contamination level of the sediments, and the characteristics of the dredged material disposal site. Whether project reviewer or proponent, being able to anticipate where problems might occur in the process and addressing the appropriate issues will do much to expedite projects.

## DREDGING TECHNOLOGIES: DIGGING IT OUT

Each dredging project is unique; types of sediment vary, currents and tides differ, disposal areas are near, or far away. Consequently, many types of dredges have been developed to meet these varying needs. Dredging a navigation channel in Boston Harbor with sediments comprised of contaminated silts and clays is markedly different from cleaning out a tidal inlet through a barrier beach system on Cape Cod. Both of these projects involve the removal of sediment but the similarity ends there. Sediment type, level of contamination, mode of disposal and size and configuration of channel cut all factor into the selection of the appropriate dredge type. As with all other aspects of dredging, proper planning is essential to provide a "best fit" between project and the type of dredge selected.

Dredges fall into three major categories:

1. mechanical- those which remove sediment by physically digging into it and bringing it to the surface inside a bucket or other similar containment vessel

2. hydraulic- those which remove sediment by suction, sometimes disturbing it first with a cutter-head or water jets, and pumping the slurry of water and sediment into a containment vessel or through a discharge pipe directly to the disposal site.

3. pneumatic- those which remove sediments by using an unbalanced hydrostatic head, or compressed air, to draw material into a submerged containment chamber, from which it is pumped to the surface with compressed air

Table 2.1 summarizes these dredge types and provides an overview of the good and not so good points of each type. Table 2.2, from Bray [1979], uses the same format but shows, in greater detail, the spectrum of dredge types and how they differ in configuration and modes of transport and disposal. Each variation was designed for maximum operational efficiency within a specific subset of factors and conditions. It is the task of the project planner to determine, all else being equal, which dredge type is particularly suited to the project at hand.

Assembled from Bray [1979], Mohr [1974] and Herbich and Brahme [1983], Table 2.3 is are a synopsis of relevant information on each of the most common dredge types, detailing how each dredge goes about removing the material, how much suspended sediment it typically stirs up in the process, how it responds to various physical and spatial constraints, the character and consistency of the material after removal, and a schematic drawing to provide a general idea of its appearance.

## TABLE 2.1 - SUMMARY: TYPES OF DREDGES

| TYPE | EXAMPLES | BENEFITS | LIABILITIES |
|---|---|---|---|
| Mechanical | Clamshell<br>Chain Bucket<br>Dipper<br>Dragline | -relatively little disturbance to material<br>-extraction at near in-situ densities (little disturbance to material as it is removed)<br>-settling basins unnecessary<br>-can be used for wide variety of materials, particularly good for consolidated clays and other hard materials | -significant amount of spillage and leakage<br>-depth of penetration difficult to control, typically +/- 1 foot<br>-slow process, especially if material must be rehandled or transported, increasing project cost |
| Hydraulic | Cutterhead<br>Plain Suction<br>Dustpan<br>Sidecast<br>Hopper | -good control over what is dredged<br>-generally least expensive per cu. yd. removed<br>-if done correctly, low turbidity at dredge site<br>-good for larger and more extensive projects | -significant amount of material to deal with (4 water: 1 sediment)<br>-requires settling basins, flocculation and filtration<br>-sometimes difficult to separate slurry<br>-high turbidity generation potential if done incorrectly<br>-except for hopper dredges, distance to disposal site should be short (less than a mile) |
| Pneumatic | Amtec Pump<br>Oozer Pump<br>Pneuma System | -low water volume in slurry (1:4)<br>-very low turbidity generation<br>-good control over depth and location of cut<br>-good for removal of contaminated sediments | -very expensive<br>-low availability<br>-not widely used in U.S...may require special training for crews<br>-not appropriate for sediments coarser than silts<br>-may require depths of 30-40 feet (100 ft. optimum) |

TABLE 2.2 - CLASSIFICATION OF DREDGES [Bray 1979]

| Main classification | Individual type | Method of extraction | Method of transportation | Method of disposal |
|---|---|---|---|---|
| Mechanical | Dipper dredger | Face shovel | Barge | Bottom discharge, grab or suction pump |
| | Backhoe dredger | Backhoe bucket | Barge | Bottom discharge, grab or suction pump |
| | Stationary bucket dredger | Bucket chain | Barge | Bottom discharge, grab or suction pump |
| | Self-propelled bucket dredger | Bucket chain | Barge | Bottom discharge, grab or suction pump |
| | Self-propelled hopper bucket dredger | Bucket chain | Own hold | Bottom discharge, grab or suction pump |
| | Pipeline bucket dredger | Bucket chain | Pipeline | Pipeline |
| | Dragline | Drag bucket | Barge | Bottom discharge, grab or suction pump |
| | Stationary grab dredger | Grab | Barge | Bottom discharge, grab or suction pump |
| | Self-propelled grab dredger | Grab | Own hold | Bottom discharge, grab or suction pump |
| Hydraulic | Stationary suction dredger | Suction head (primary)<br>Centrifugal pump (secondary) | Pipeline or barge | Pipeline<br>Bottom discharge, grab or suction pump |
| | Jet pump suction dredger | Suction head (primary)<br>Jet pump (secondary) | Pipeline or barge | Pipeline<br>Bottom discharge, grab or suction pump |
| | Hopper suction dredger | Suction head (primary)<br>Centrifugal pump (secondary) | Own hold | Pipeline or bottom discharge |
| | Cutter suction dredger | Cutter head (primary)<br>Centrifugal pump (secondary) | Pipeline | Pipeline |
| | Bucket wheel excavator | Bucket wheel (primary)<br>Centrifugal pump (secondary) | Pipeline | Pipeline |
| | Trailing suction hopper dredger | Draghead (primary) (with or without water jets or blades)<br>Centrifugal pump (secondary) | Own hold | Bottom dump or pipeline |
| | Trailing suction sidecasting dredger | Draghead (primary) (with or without water jets or blades)<br>Centrifugal pump (secondary) | Natural process | Natural process |
| | Dustpan dredger | Dustpan head with water jets (primary)<br>Centrifugal pump (secondary) | Pipeline | Natural process |
| Pneumatic | 'Pneuma' dredger<br>'Ooze' dredger | Suction head (primary) (and drag head if necessary)<br>Seabed pump (secondary) | Pipeline or barge | Pipeline<br>Bottom discharge, grab or suction pump |
| | Air lift dredger | Suction head (primary<br>Air lift | Barge | Bottom discharge, grab or suction pump |

TABLE 2.3 DRAGLINE DREDGE

TYPE: Mechanical

DREDGING PRINCIPLE: Scrapes off material by sliding drag bucket toward dredging platform...lifts bucket and deposits material on conveyance or at disposal area.

TURBIDITY GENERATION POTENTIAL: Undocumented but thought to be high given exposure of sediment to the water column as it is dragged along the sediment surface and lifted from the bottom.

WORKING ANCHORAGE REQUIRED: Spuds or anchors must be used.

ABILITY TO WORK IN...SWELLS AND WAVES: Capable of working in "moderate" seas...problems with bucket control and operational efficiency can be expected in swells greater than 1.0 M.

...CURRENTS: Problem in positioning drag head or bucket in stronger currents...if mounted dumb (i.e. not on a self-propelled platform), higher current velocities ( > 2 knots) may make repositioning of the platform difficult.

...PROXIMITY TO STRUCTURES: Except for overhead bridges. can work close if adequate room to allow unrestricted movement of crane derrick.

...MARITIME TRAFFIC: Barges usually more of a problem than platform...most are reasonably maneuverable and suited to working in confined areas.

DREDGED MATERIAL DENSITY: Approaches in-situ density in mud and silt...approaches dry density in coarser materials.

SPATIAL REQUIREMENTS...WIDTH: Width of platform + width of two barges + 10 M (if dumb) based on minimum turning width at water level.

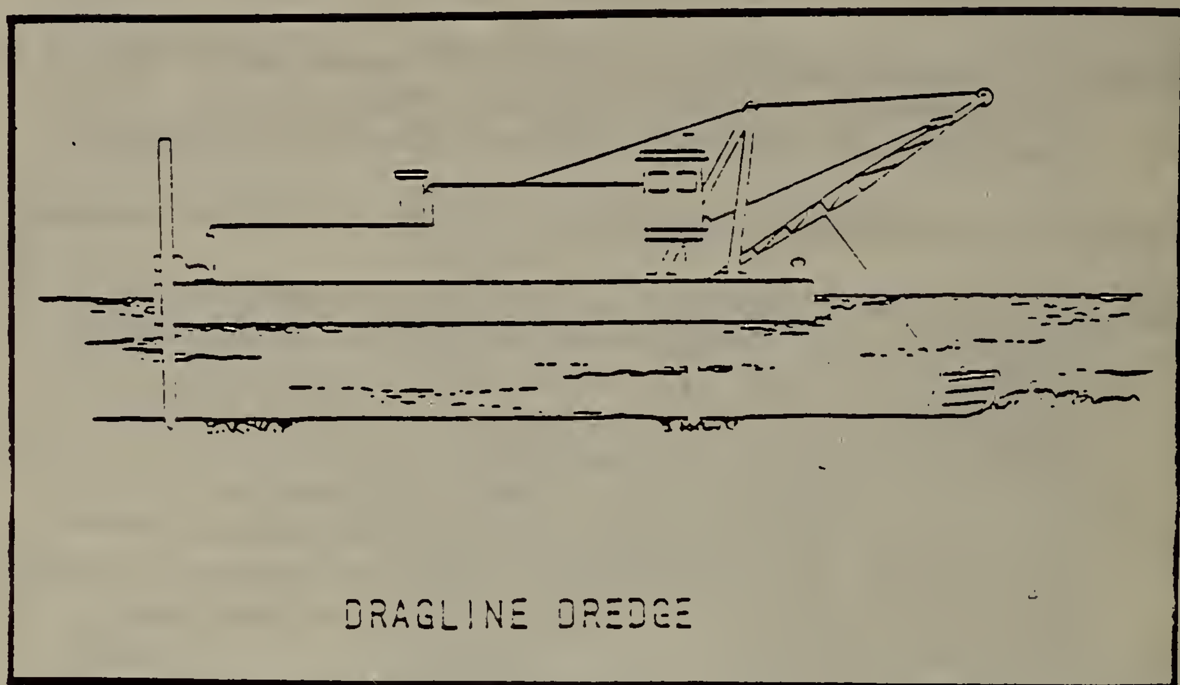
...LENGTH: Unlimited...not designed for efficient dredging of long channels.

...DEPTH: Usually used in shallow or intertidal areas ...maximum depth to functional length of spuds (if used) ...minimum depth is draft of platform- if cooling water for the machinery is taken from beneath the platform, minimum depth must be significantly increased to prevent intake of suspended sediment.

...THICKNESS OF MATERIAL: Efficiency depends on weight and size of drag head (e.g. heavier drag produces deeper cut in materials of equal density).

GENERAL COMMENTS: Not built exclusively for sub-aqueous excavation but sometimes used in intertidal and adjacent upland applications...low production for its size.

FIGURE 2.1 DREDGE OUTLINES from Malcolm Pirnie, Inc. (1978)



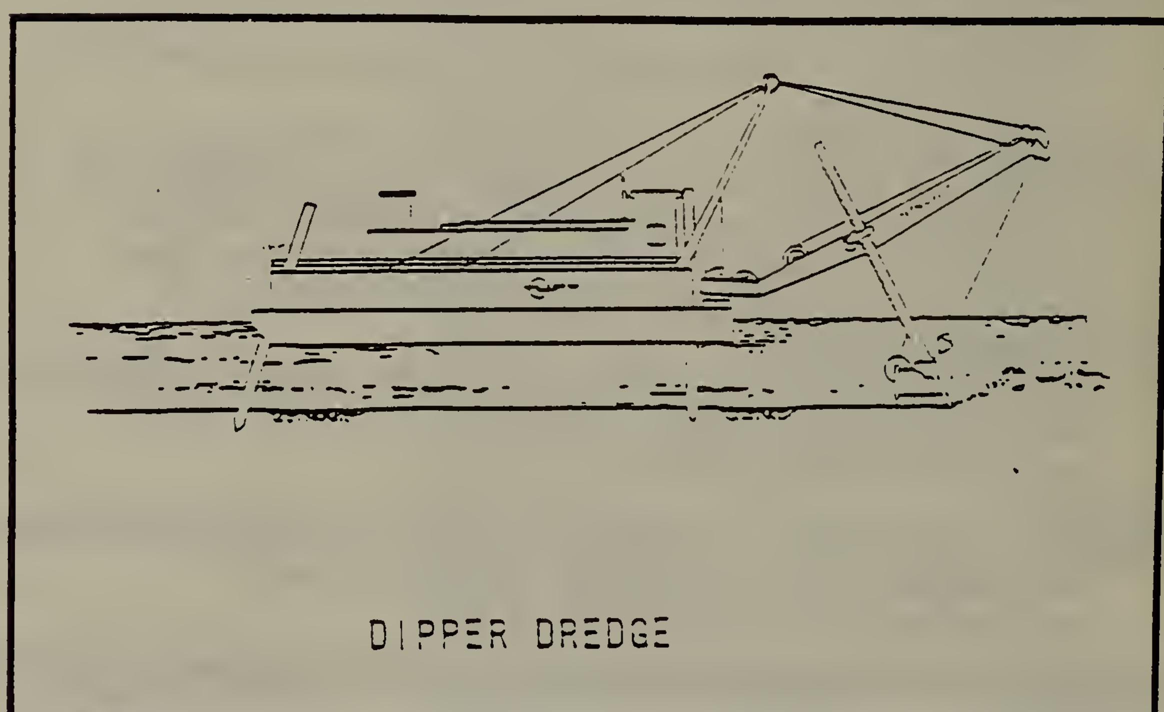



TABLE 2.3 (CONT.) DIPPER DREDGE

TYPE: Mechanical

DREDGING PRINCIPLE: Breaks off material by forcing cutting edge of single shovel into it while dredge is stationery...lifts material to conveyance or deposits at disposal site.

TURBIDITY GENERATION POTENTIAL: Undocumented but thought to be moderate to low given that materials removed by this type of dredge are usually gravels to boulders and other types of rock...would be high if used to dredge unconsolidated silts or clays.

WORKING ANCHORAGE REQUIRED: Several heavy spuds.

ABILITY TO WORK IN...SWELLS AND WAVES: Very sensitive to swell... acceptable only if platform in "jacked-up" position on spuds ...recommended no more than 0.3 M...inefficient at 0.6 M
...CURRENTS: Operational efficiency significantly reduced in currents $\geq$ 3 knots.
...PROXIMITY TO STRUCTURES: Can work very close.
...MARITIME TRAFFIC: Barges usually more of a problem than dredge...because spuds must be used, moving quickly presents problems unless dredge has walking spud on stern

DREDGED MATERIAL DENSITY: approaches in-situ density for mud and silt...approaches dry density in coarser materials.

SPATIAL REQUIREMENTS...WIDTH: Width of dredge + width of two barges based recommended minimum
...LENGTH: Unlimited...not designed for efficient dredging of long channels.
...DEPTH: Maximum depth depends on functional length of spuds and/or bucket arm...minimum is draft of dredger unless cooling water is a problem.
...THICKNESS OF MATERIAL: Unrestricted

GENERAL COMMENTS: Good for harder and very consolidated materials... excellent for rock and gravel of all types.

TABLE 2.3 (CONT.) CONTINUOUS CHAIN BUCKET DREDGE

TYPE: Mechanical

DREDGING PRINCIPLE: Removes material by forcing single cutting edge of successive buckets into material while dredge is slowly moved between anchors...lifts buckets to surface and deposits material in conveyance or into own hoppers.

TURBIDITY GENERATION POTENTIAL: Undocumented but thought to be potentially significant given exposure of the material to the water column as it is lifted from the bottom.

ABILITY TO WORK IN...SWELLS AND WAVES: Extremely sensitive due to high superstructure and critical bucket chain position with respect to the sediment surface...0.4 M limiting...1.0 M inefficient and/or dangerous.

...CURRENTS: Can work efficiently in up to 3 knots given sufficient anchorage.

...PROXIMITY TO STRUCTURES: Can work close only if the dredging depth is relatively shallow and there is a suitable way to position the head wire and bucket chain

...MARITIME TRAFFIC: Dredge has particularly long head wire and five other wires serving various purposes which may cause a hazard to navigation...attendant barges may also be a problem.

DREDGED MATERIAL DENSITY: Approaches in-situ density for mud and sand...approaches day density for coarser materials.

SPATIAL REQUIREMENTS...WIDTH: Restricted to width of dredger + barge + angle to allow bucket chain to reach side slope of cut... 1.5 X length of dredger minimum based on approximate turning width.

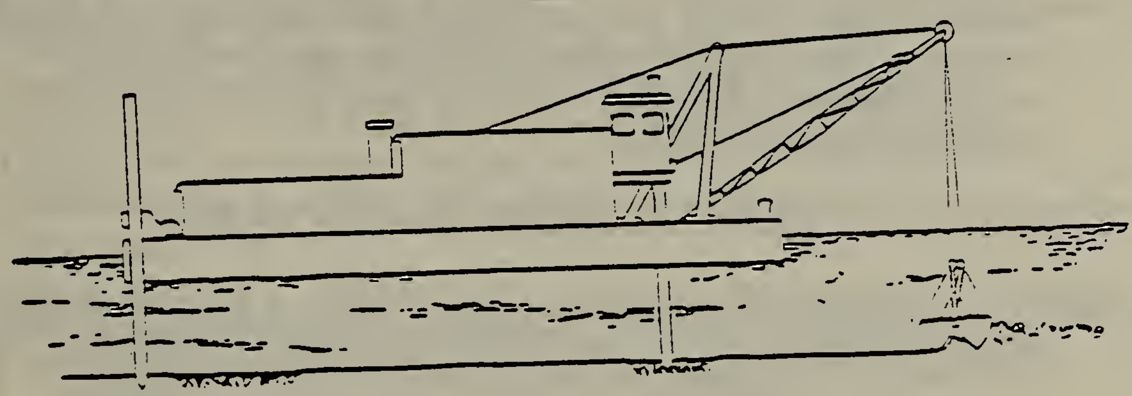
...LENGTH: Unrestricted

...DEPTH: Minimum restricted to draft of dredger (ave. 2-5 M) unless cooling water problem...maximum depends on length, maximum downward extension and angle of bucket chain as well as certain power requirements.

...THICKNESS OF MATERIAL: Like all mechanical dredgers, it is inefficient if material is of insufficient thickness to allow buckets to be completely filled during each cycle... better for projects where thicker cuts are required.

GENERAL COMMENTS: Not widely used in U.S, one example of use in New England where one is usually used for sand and gravel mining on the Housatonic River in Connecticut...high production for its size

FIGURE 2.1 (cont.) from Malcolm Pirnie, Inc. (1978)



CLAMSHELL DREDGE

BUCKET DREDGE

TABLE 2.3 (CONT.) CLAMSHELL/GRAB DREDGE

TYPE: Mechanical

DREDGING PRINCIPLE: Removes material by forcing opposing bucket edges into sediment, confining the material within the bucket so that it can be lifted from the bottom to conveyance or directly into disposal area

TURBIDITY GENERATION POTENTIAL: Known to be quite high...four major sources: 1) resuspension from impact and lifting from bottom, 2) erosion of sediment as bucket is lifted, 3) further loss as bucket breaks surface of water, 4) turbid water draining from between jaws...greatest potential from dredging fine and unconsolidated sediments...can be reduced 30-70% by use of sealed or gasketed bucket.

WORKING ANCHORAGE REQUIRED: Spuds or anchors.

ABILITY TO WORK IN...SWELLS AND WAVES: Can work in up to moderate seas...not too sensitive since mode of dredging is indirect (i.e. bucket is attached to dredge only by cable)...holding position of the platform and control of bucket position are primary problems...if self-propelled, recommended maximum of 2.5 M, above 3.5 M considered dangerous and inefficient... if dumb (mounted on barge), up to 0.4 M recommended maximum, above 1.0 M not considered practical.
...CURRENTS: Problem in positioning grab bucket in stronger currents...less of a problem in shallower water.
...PROXIMITY TO STRUCTURES: Very suitable for close work.
...MARITIME TRAFFIC: Barges usually more of a problem than dredge.

DREDGED MATERIAL DENSITY: Approached in-situ density in mud and silt...approaches dry density in coarser materials.

SPATIAL REQUIREMENTS...WIDTH: based on minimum turning width, width of dredge + barge + 10 M.
...LENGTH: unlimited, but more suited for smaller and confined areas.
...DEPTH: Minimum, draft of loaded vessel...maximum theoretically limited to length of cable on crane and length of anchor lines but, in all but still waters, deeper ( > 15 M) water presents significant difficulties in positioning bucket ...with increasing depth comes decreases in operational efficiency and productivity.
...THICKNESS OF MATERIAL: Penetration of bucket is dependent on weight, configuration, sediment type and expertise of operator...inefficient when thickness of material is insufficient to allow bucket to be completely filled during each cycle.

GENERAL COMMENTS: Most widely used dredge type in Massachusetts by virtue of its wide availability...used mostly for small ( < 10,000 CY) projects...generally the only choice for smaller projects involving unconsolidated silts due to the cost and technical problems associated with the hydraulic disposal of this material...low production for its size

TABLE 2.3 (CONT.) CUTTERHEAD SUCTION DREDGE

TYPE: Hydraulic

DREDGING PRINCIPLE: Material disturbed with rotary cutter... unconsolidated material picked up with dilution water by suction pipe...slurry pumped through discharge pipe to conveyance or disposal site.

TURBIDITY GENERATION POTENTIAL: Most of turbidity generated at cutterhead...can be significant if not being operated efficiently...mostly confined to near-bottom areas adjacent to cutterhead...dredging fine grained materials with cutter at high RPM taking deep cuts on each swing has the greatest potential for producing high suspended sediment concentrations.

WORKING ANCHORAGE REQUIRED: Except for the smallest of this type, which only uses anchors, two spuds ("working" and "walking", so-called) and two swing anchors are utilized.

ABILITY TO WORK IN...SWELLS AND WAVES: Dredge very sensitive to sea state due to cutterhead position relative to bottom...floating discharge line also sensitive...can substitute wires and anchors for spuds in most severe conditions but operational efficiency greatly reduced...small dredges, 0.2 M considered maximum for efficient operation, above 0.4 M unworkable... large dredges, 0.4 M maximum efficient, 0.8 M unworkable.

...CURRENTS: Generally held 2 knot maximum current...problems with lateral pressure on ladder from crosscurrents and stress on joints in floating pipeline.

...PROXIMITY TO STRUCTURES: Can work reasonably close if dredging in shallow areas (i.e. if ladder and cutterhead protrude well beyond bows of dredger)...otherwise, unsuitable.

...MARITIME TRAFFIC: Discharge pipeline sometimes a problem ...dredge cannot be moved off-site easily to accommodate traffic...mode of dredging (dredge rotating on spud between swing anchors) may act to restrict navigation in relatively narrow channels.

DREDGED MATERIAL DENSITY: Diluted to slurry with average density of 1200 g/l or approx. 4:1 ratio of water to sediment.

SPATIAL REQUIREMENTS...WIDTH: Based on minimum turning distance, minimum width is length of dredge with ladder raised to waterline...area must be wide enough to dredge to toe of sideslope without hull fouling bank on either side.

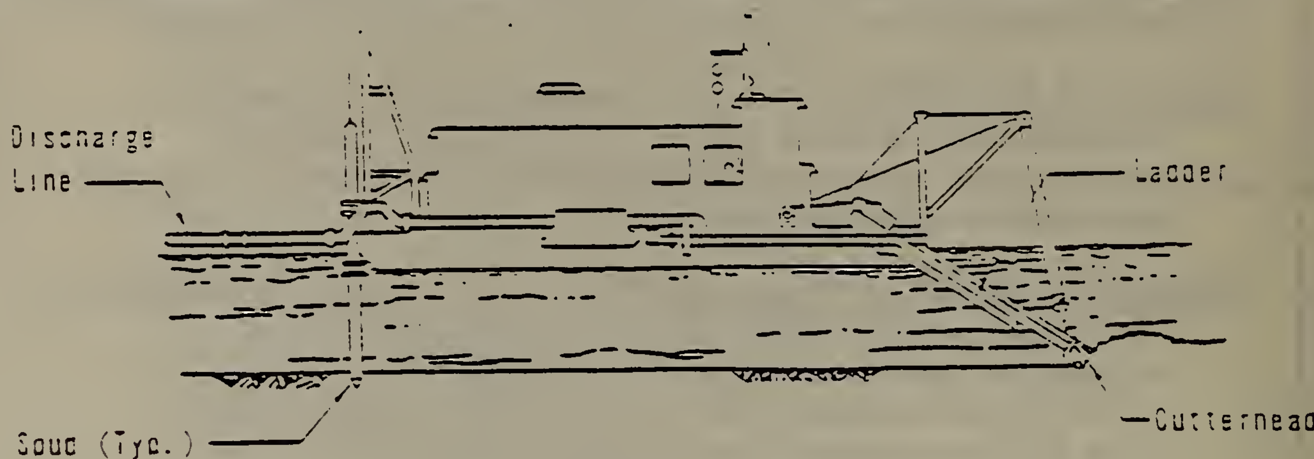
...LENGTH: Unrestricted.

...DEPTH: Restricted to maximum downward extension of ladder and functional length of spuds.

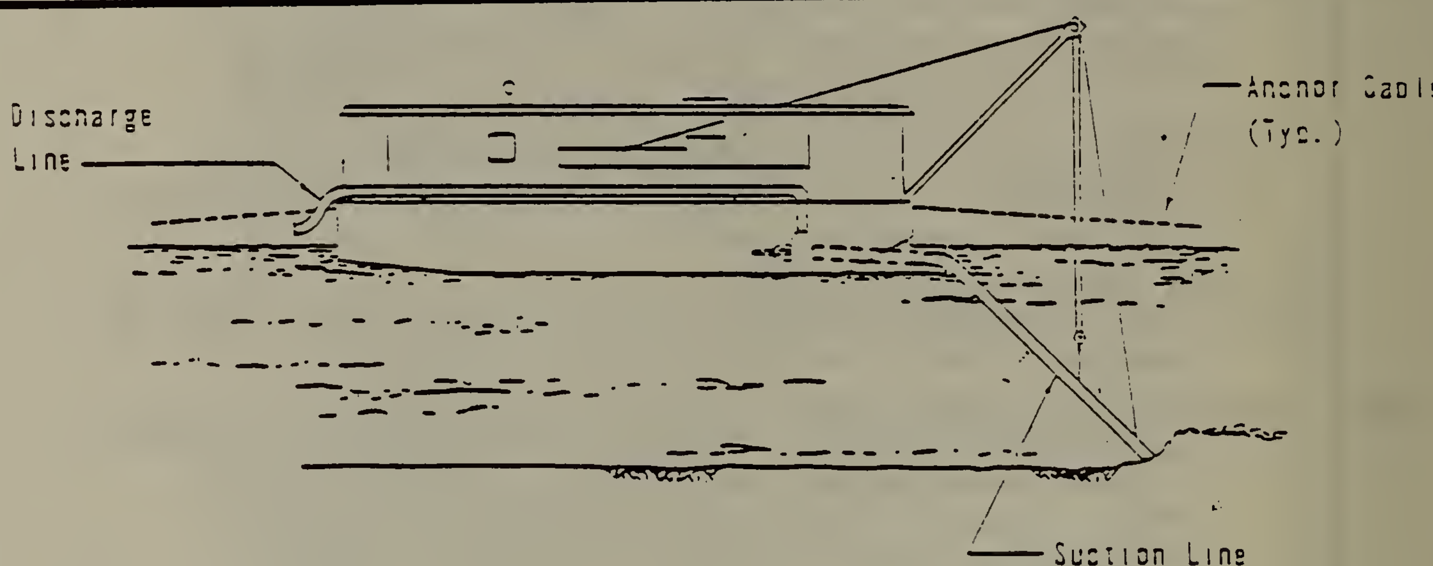
...THICKNESS OF MATERIAL: Better for thinner cuts but type of material also important (e.g. cohesive sediments difficult to cut deeply.

GENERAL COMMENTS: Most commonly used dredge in U.S. especially for larger projects...high production for size of plant.

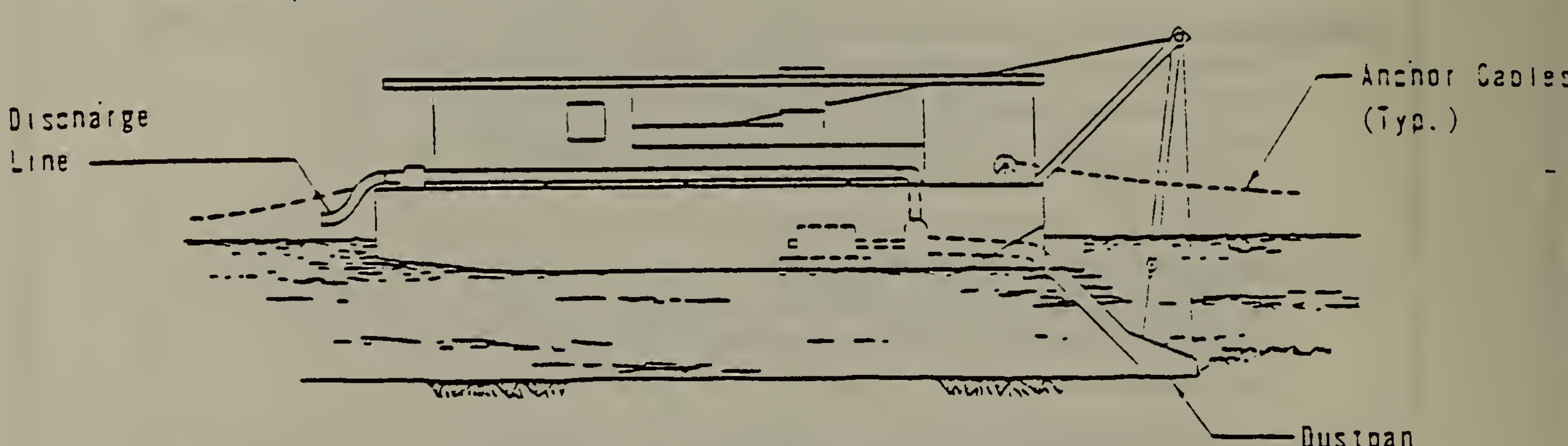
FIGURE 2.1 (cont.) from Malcolm Pirnie, Inc. (1978)




CUTTERHEAD SUCTION DREDGE




PLAIN SUCTION DREDGE




DUSTPAN DREDGE

TABLE 2.3 (CONT.) PLAIN SUCTION DREDGE

TYPE: Hydraulic

DREDGING PRINCIPLE: Material is removed by suction and transported in slurry form through discharge pipeline to conveyance or disposal site...water jets sometimes used to disturb and fluidize sediments to increase operational efficiency.

TURBIDITY GENERATION POTENTIAL: low unless water jets utilized.

WORKING ANCHORAGE REQUIRED: Two anchors secured upstream.

ABILITY TO WORK IN...SWELLS AND WAVES: very sensitive...distance between suction head and sediment critical for effective operation...failure of floating pipeline also may be a problem in higher sea states...critical wave heights cited for cutterhead suction dredge relevant here as well.

...CURRENTS: Generally held 2 knot maximum for operational efficiency...problems with floating pipelines and cross-currents on ladder.

...PROXIMITY TO STRUCTURES: Can work reasonably close if water is relatively shallow, allowing ladder and siphon head to extend beyond the bows of the dredge...otherwise unsuitable

...MARITIME TRAFFIC: Floating discharge pipeline may present certain problems...cannot be easily moved off-site to accommodate traffic.

DREDGED MATERIAL DENSITY: diluted to slurry with average density of 1200 g/l or 4:1 ratio of water to sediment.

SPATIAL REQUIREMENTS...WIDTH: Based on minimum turning distance, length of dredge with ladder raised to water level...cut must be wide enough to dredge to toe of slope without grounding hull on bank.

...LENGTH: Unrestricted

...DEPTH: Maximum downward extension of ladder and suction head.

...THICKNESS OF MATERIAL: As with all hydraulic dredges, thinner cuts are better...type and character of material important...highly cohesive sediments difficult to remove without agitation or disturbance of some sort.

GENERAL COMMENTS: Works best in unconsolidated and non-cohesive sands...highly productive for size of plant if suitable material...Dustpan Dredge a type of plain suction dredge which is used, in the U.S., only in the Mississippi River.

TABLE 2.3 (CONT.) HOPPER DREDGE

TYPE: Hydraulic

DREDGING PRINCIPLE: Material is removed and picked up together with dilution water by draghead sliding over bottom and flows through suction piping, pump and discharge piping into hoppers of vessel.

TURBIDITY GENERATION POTENTIAL: Can create significant turbidity through: 1) resuspension of sediments as drag arm is pulled across the bottom, 2) turbulence created by vessel from wake or propeller wash, 3) dispersion of material at the dredged material disposal site, 4) overflow of turbid water during the hopper filling process, the last having the greatest potential for turbidity generation. Given that most applications are dredging coarse sands, turbidity may be significantly less of a problem than of finer materials.

WORKING ANCHORAGE REQUIRED: Works while moving.

ABILITY TO WORK IN...SWELLS AND WAVES: Moderately insensitive to sea state...small hopper dredges operationally limited to 1.5 M wave heights, considered dangerous or highly inefficient at 2.5 M...larger dredges limited at 2.0 M, maximum of 4.0 M.
...CURRENTS: Operational problem only at confined sites... may strongly affect size and extent of turbidity plume from hopper overflows.
...PROXIMITY TO STRUCTURES: Can dredge as close as navigational conditions permit...not suited to working in confined areas.
...MARITIME TRAFFIC: Because of relative mobility, conflicts can be easily avoided.

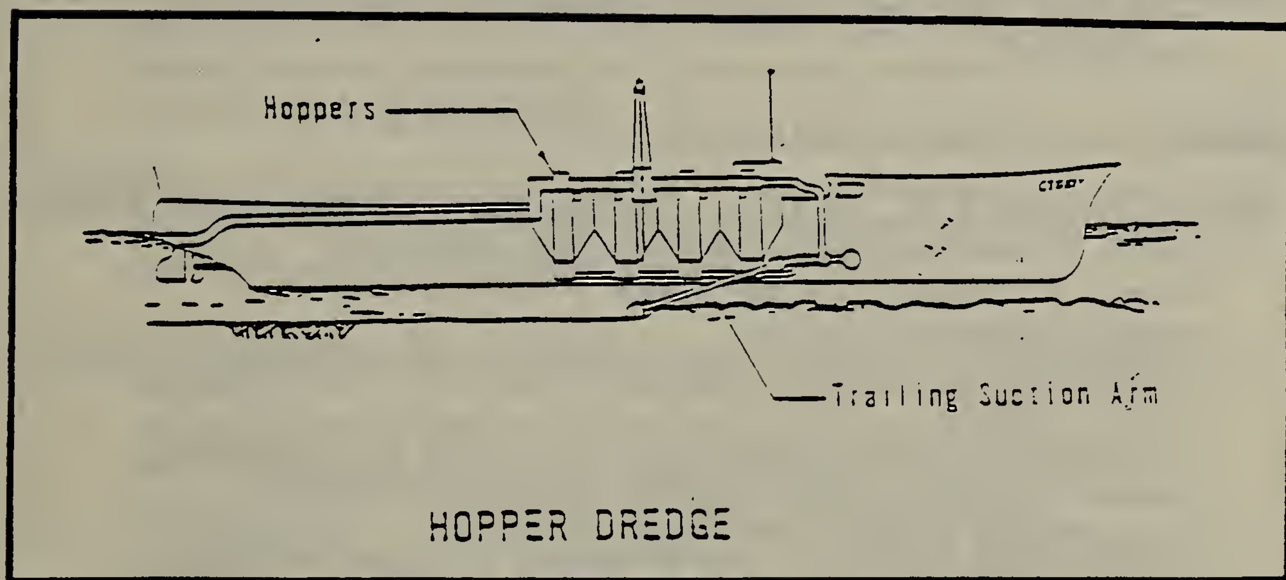
DREDGED MATERIAL DENSITY: Sediment diluted to a slurry with a suspended sediment concentration of approximately 1200 g/l or a 4:1 ratio of water to sediment.

SPATIAL REQUIREMENTS...WIDTH: Based on minimum turning distance, 4 X length of vessel (without bow thrusters), 2.5 X length (with bow thrusters). Certain dredges may be able to turn within their length.
...LENGTH: < 500 M considered restrictive, > 1000 M most effective.
...DEPTH: Restricted to maximum downward extension of drag arm.
...THICKNESS OF MATERIAL: As with all hydraulic dredges, thinner cuts provide greater efficiency.

GENERAL COMMENTS: Widely used by the U.S. Army Corps of Engineers for Federal navigation projects...best suited to busy waterways with heavy ship traffic and/or rough waters... production depends on travel time to dump and mode of discharge...discharge of material from hoppers through doors on bottom of vessel, through split hull configurations or, less frequently, pumped out through discharge pipe for beach nourishment activities...given problems with settling of finer materials in hopper, rarely used for anything but sand.

FIGURE 2.1 (cont.)

from Malcolm Pirnie, Inc. (1978)



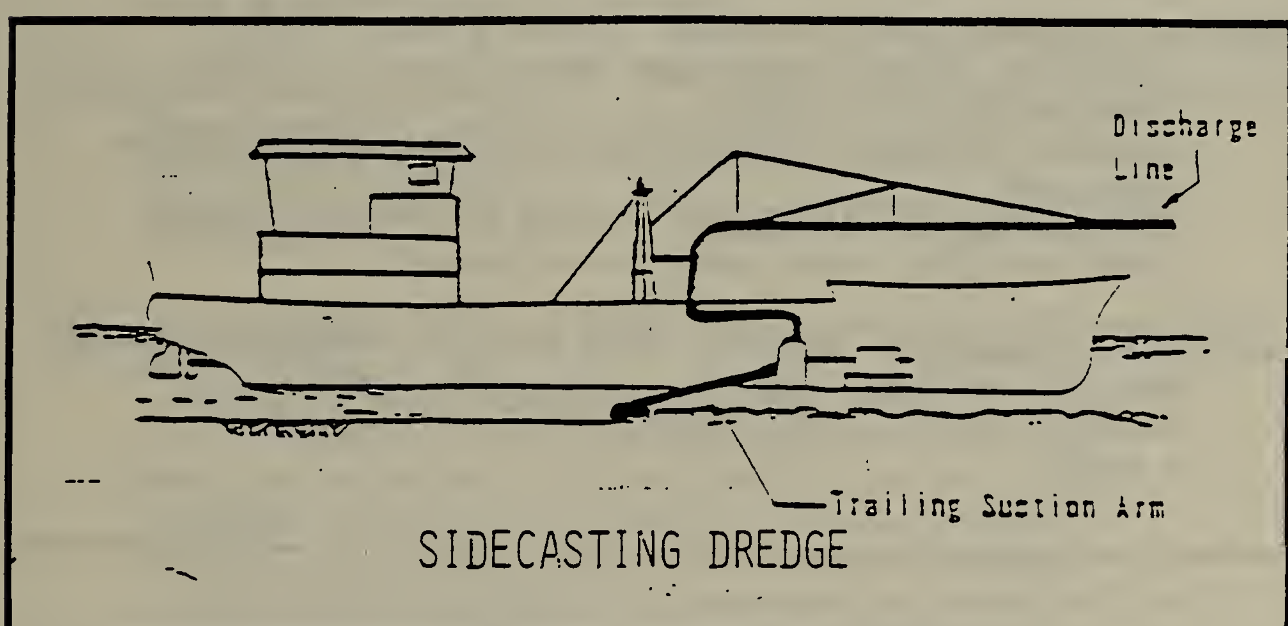



TABLE 2.3 (CONT.) SIDECASTING DREDGE

TYPE: Hydraulic

DREDGING PRINCIPLE: Material is removed and picked up with dilution water by draghead sliding over bottom and is pumped over the side of the moving vessel or onto an adjacent upland area.

TURBIDITY GENERATION POTENTIAL: Because this dredge is used almost exclusively with sand, suspended sediment levels generated are usually low.

WORKING ANCHORAGE REQUIRED: Works while moving.

ABILITY TO WORK IN...SWELLS AND WAVES: Much like hopper dredge in that it is relatively insensitive to sea state unless sea state is particularly high and dredge is working close to beach or other upland area.
...CURRENTS: Most likely not a problem except in confined areas or inlets.
...PROXIMITY TO STRUCTURES: Not suited to working near structures...groins, jetties and other engineered structures may present particular operational problems.
...MARITIME TRAFFIC: Due to mobility of dredge, conflicts traffic not usually a problem.

DREDGED MATERIAL DENSITY: Material diluted to a slurry with a suspended sediment concentration of approx. 1200 g/l or a 4:1 ratio of sediment to water.

SPATIAL REQUIREMENTS...WIDTH: Similar to hopper dredge
...LENGTH: Probably unrestricted though longer sites allow greater operational efficiency.
...DEPTH: Related to maximum and minimum extension positions of drag arm.
...THICKNESS OF MATERIAL: As with all hydraulic dredges, thinner cuts allow greater operational efficiency.

GENERAL COMMENTS: Especially useful for quick maintenance of tidal inlets, but results are usually short-term. The Corps of Engineers owns the entire existing fleet (2 or 3) of this type of dredge

TABLE 2.3 (CONT.) PNEUMA/OOZE PUMP DREDGES

TYPE: Pneumatic

DREDGING PRINCIPLE: Material is removed by creating a pressure differential between a receiving chamber and its ambient environment which draws it into the chamber...material is pumped to discharge line by addition of compressed air.

TURBIDITY GENERATION POTENTIAL: very low...all versions of dredge tested show turbidity at dredge site rarely exceeds background levels...possible resuspension on impact with sediment surface and during recovery.

WORKING ANCHORAGE REQUIRED: Variable depending on type of vessel on which pumps are mounted (usually mounted on a ladder as in cutterhead suction configuration).

ABILITY TO WORK IN...SWELLS AND WAVES: Variable depending on configuration of vessel on which pumps are mounted...if set up like cutterhead suction dredge, would be quite sensitive to sea conditions...if pumps suspended from a cable, should be able to work in more severe conditions.
...CURRENTS: Variable depending on how pumps are deployed (ladder or cable) and type of transport vessel used.
...PROXIMITY TO STRUCTURES: If ladder configuration, could work reasonably close to structures if ladder and pumps extend beyond the bows of the dredge...if cable mounted, can work in areas directly adjacent to structures.
...MARITIME TRAFFIC: Variable depending on configuration of vessel on which pumps are mounted.

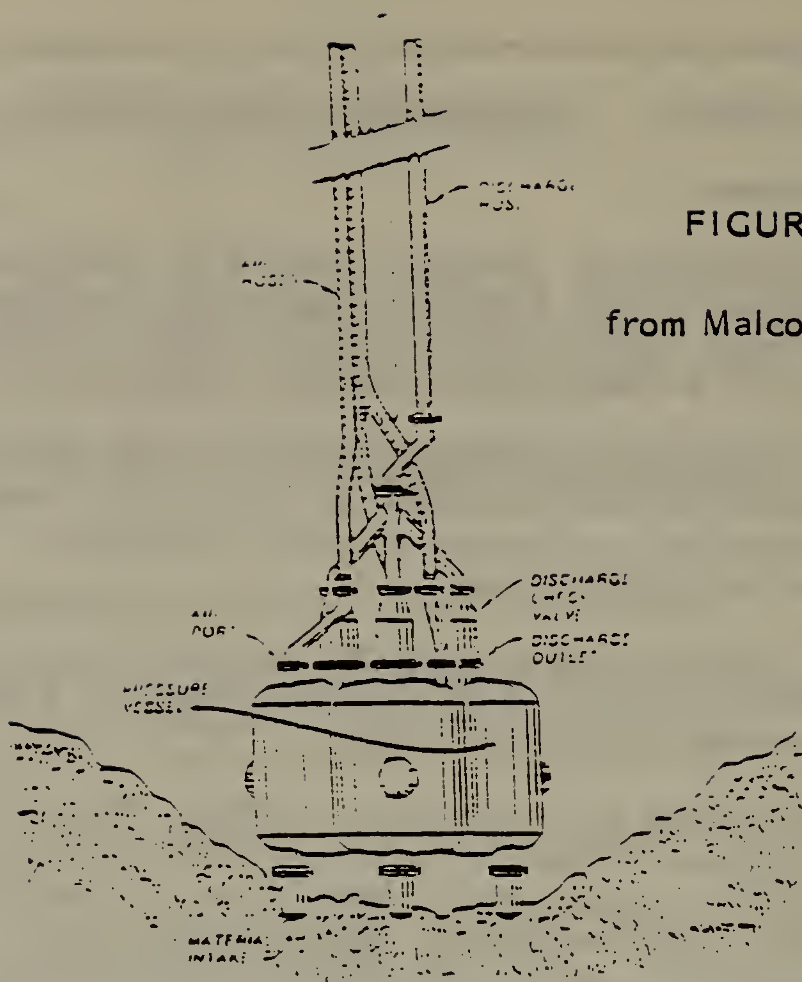
DREDGED MATERIAL DENSITY: Low water content...approaches in-situ in the majority of cases...at best 1:4 ratio of water to sediment...representative test results: 60% solids- Ooze Pump; 60-80% solids- Pneuma Pump; 30-53% solids- field test of Pneuma Pump.

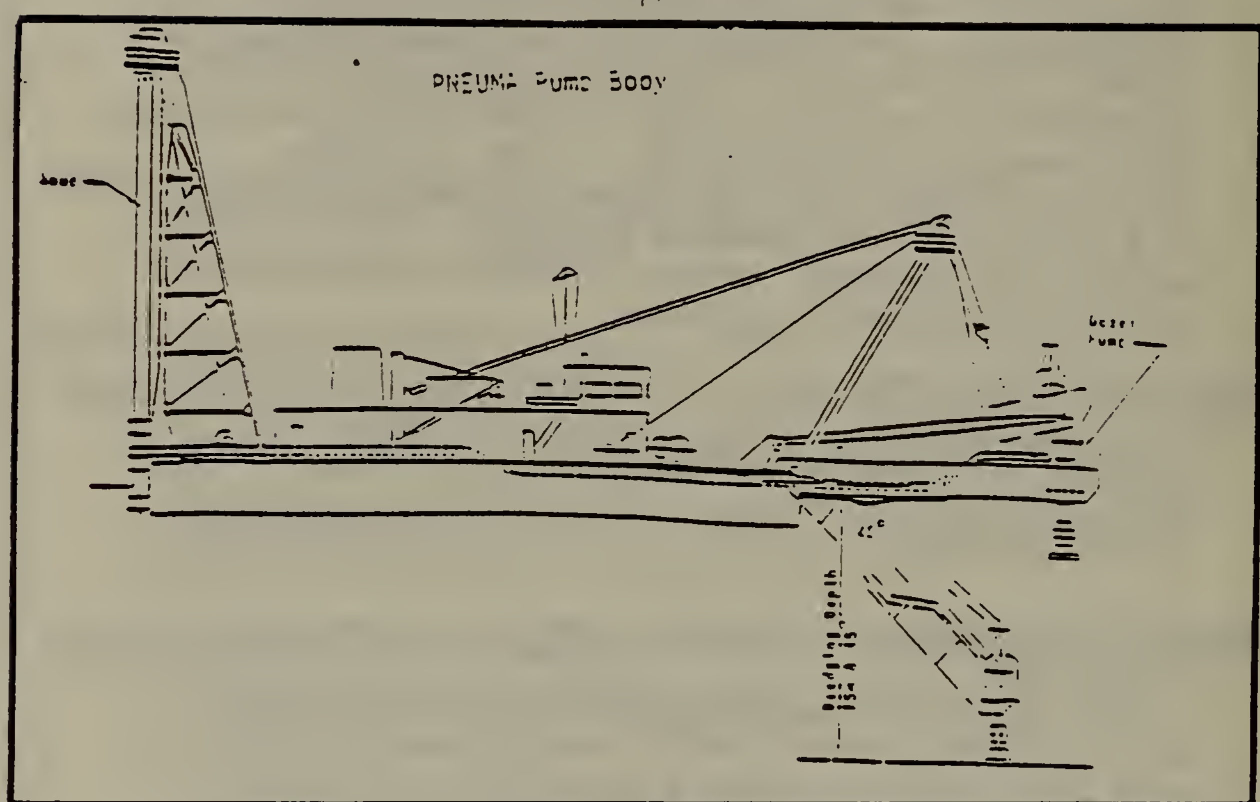
SPATIAL REQUIREMENTS...WIDTH: Higher operational efficiency in smaller areas.
...LENGTH: Again, operational efficiency better for smaller areas...in general, better suited to removing materials from basin areas which act as settling basins for fine materials.
...DEPTH: Requires 10-15 M depth...maximum efficiency at 30-35 M...limits usage for purposes of channel dredging.
...THICKNESS OF MATERIAL: operational efficiency increases if chamber fills completely on each cycle...thickness of sediment accommodated depends on capacity of chamber.

GENERAL COMMENTS: Has great potential of removal of grossly contaminated sediments...used widely for this purpose in Japan...has been used only a few times in the U.S. ...a few variants have been developed which will work at shallower depths...mobilization costs are extremely high and crews trained to use this equipment are rare...very low productivity for its size and cost...works best in unconsolidated silts and silty clays...not efficient in sand.

FIGURE 2.1 (cont.)

from Malcolm Pirnie, Inc. (1978)



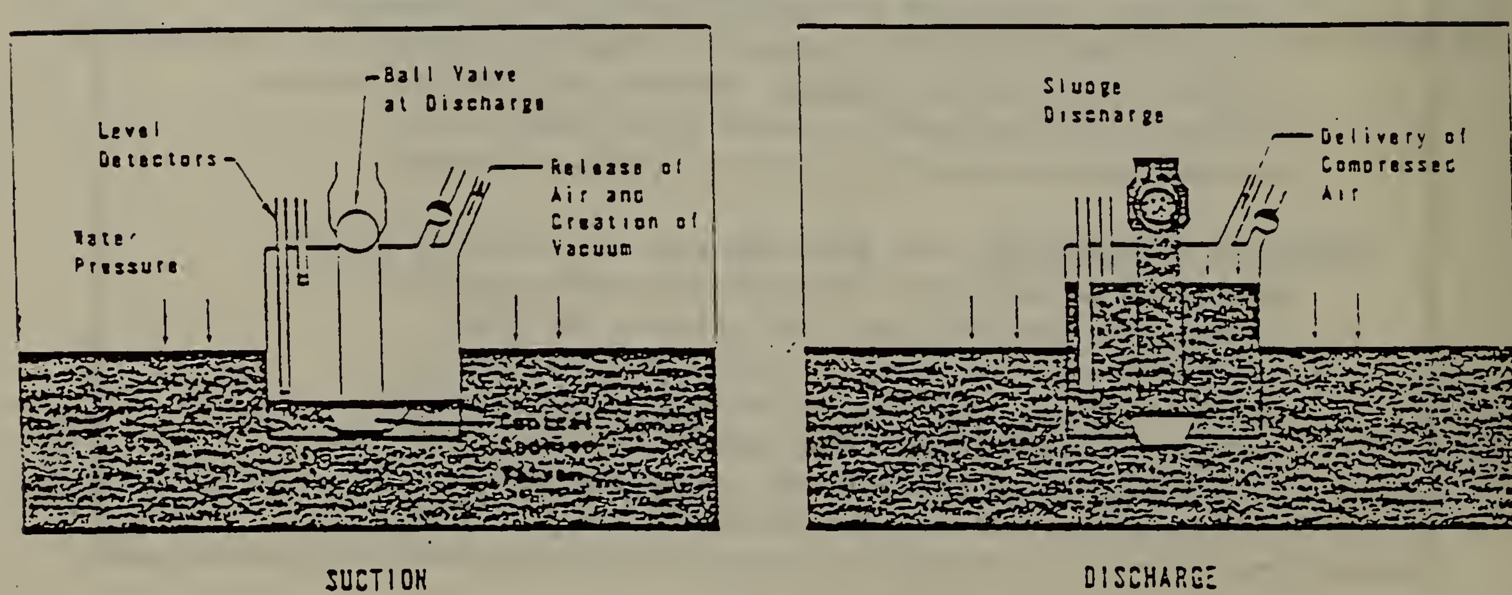
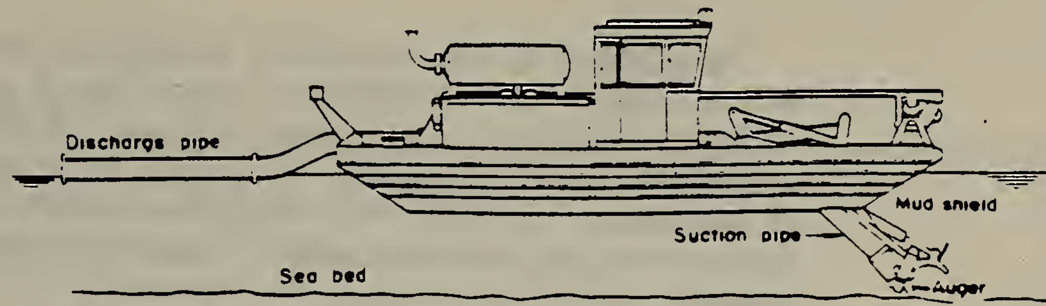


FIGURE 2.2

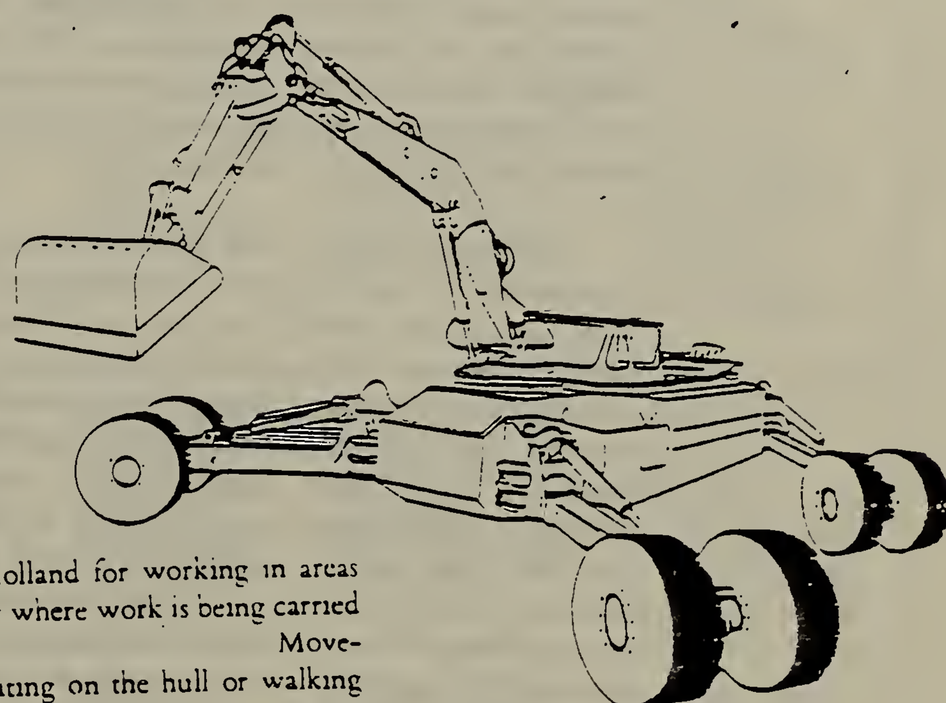
MISC. SPECIALTY DREDGES

(AFTER BRAY 1979)



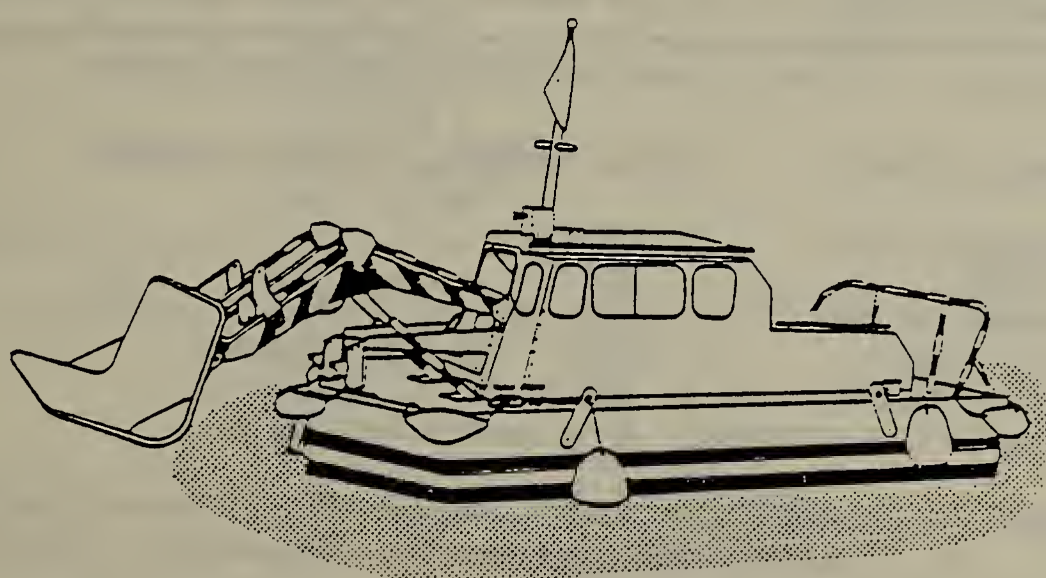

**The Mudcat**

This is a small suction dredger which collects the soil by means of two horizontal augers lowered onto the bottom. The augers draw the material inwards towards the suction head and from there it passes through the dredging pump to the discharge pipeline. The method is claimed to be environmentally advantageous due to the small amount of turbidity generated.



The Amphidredger

This is another amphibious dredger developed in Holland for working in areas where only very low bearing pressures are feasible, or where work is being carried out at the land/water interface. Movement can be achieved by rolling on the wheels, floating on the hull or walking tortoise fashion on the legs. The base machine can be used to support a backhoe, a grab or a cutter suction unit.



**The Water Witch**

This is a mini-dredger for surface or shallow water dredging. It consists of a shallow draught self-propelled hull unit on which can be mounted a small backhoe, a dipper bucket or various units for removing weed, oil, etc., from the water surface.

In addition to the information supplied in the foregoing "Field Guide to the Dredges of Massachusetts", the effect of sediment characteristics on the suitability and operational efficiency of dredges deserves a somewhat closer examination. In nearly all dredging projects, one piece of information essential to making some initial decisions regarding which dredge types may be appropriate is some description of the sediments to be dredged. Table 2.4, summarized from Bray [1979], evaluates how effective different dredges are in removing various types of material. See Bray [1979] for a more detailed discussion of this topic.

All this having been said, a bit of perspective is in order. Earlier in this discussion regarding the "best fit" between dredge type and project a reference was made to the fact that, all else being equal, the selection of the most appropriate type of dredge can be made from a careful consideration of the attributes and liabilities of each within the context of the project conditions. The "real world" demands another qualifier be added to this statement which would point out, in essence, that all things are rarely equal. Most of the decision will ultimately depend on the project budget.

Getting a dredge to a site and returning it to its home port upon completion of the project, Mobilization/Demobilization or "Mob/Demob" as it is sometimes called, can be one of the most costly aspects of any dredge project. If you find in your analysis of a particular project that a continuous bucket dredge is the most suited to your needs but the nearest one is 6000 miles away in the Netherlands, you have a problem. If however, that dredge happens to be working in New York Harbor and the owners are able to fit your project in before they head west, or you find out that they will be nearby next year and you are able to postpone the project until that time, you may be in luck. Therefore, an integral part of the "best fit" equation is availability. In terms of the Northeast, availability is usually not a problem unless you need something atypical. According to World Dredging and Marine Construction's "21st Annual Directory of Worldwide Dredge Fleets" (1987) [Table 2.5], the following dredges are available in the New England, New York, and New Jersey areas.

TABLE 2.5 - DREDGE AVAILABILITY IN THE NORTHEAST

| State (or other) | Type of Dredge and Number Available |
|---|---|
| CONNECTICUT | BC-1 |
| MAINE | CS-1 |
| MASSACHUSETTS | CS-4, BC-3 |
| NEW YORK | CS-11, BC-9, BB-3, BD-1 |
| NEW JERSEY | CS-13, BC-11, BD-1, GH-1 |
| CORPS OF ENGINEERS | S-3, SH-1, CS-1, TH-2 |

KEY: S - Suction, SH - Suction Hopper, CS - Cutterhead Suction
BC - Clamshell, BB - Backhoe, BD - Dipper, GH - Grab Hopper
TH - Trailing Arm Hopper

TABLE 2.4 (after Bray 1979)

EXCAVATION CHARACTERISTICS OF SELECTED DREDGE TYPES

| | Boulders Cobbles | Gravels | Sand | Silt | Clay |
|---|---|---|---|---|---|
| Dipper | Best suited when buried in other materials.. also good w/ loose materials | Suitable.. compactness will affect output | Suitable.. but finer sands wash out of bucket easily | Not commonly used...wash out with finer materials | Capable of dredging clay but problem w/ adhesive clays sticking to bucket |
| Cont. Bucket | Suitable for composites w/ small boulders-suitable for loose cobbles | Suitable.. compactness will affect output | Suitable but finer sands wash out of bucket | Dredges silt easily but problems w/ finer materials washing out | Possible but problems with adhesive clays sticking to bucket |
| Grab/ Clamshell | Heavier buckets must be used... grapple in addn. to reg. bucket | Suitable but heavier buckets needed for compacted beds | Excellent for med.-coarse.. cutting edges must be sharp to close | Widely used-problems w/ fines outweighed by versatility and manuverability | Must use heavier grabs w/ teeth..adhesion may be problem ..decrease production |
| Cutter-head | Un-Suitable | Suitable but pumping distances may have to be reduced to accommodate materials (or add a booster pump at considerable expense) | Suitable for all types | No problem but usually difficult to achieve consolidated fill | No problem but clay may form balls at cutterhead -can be controlled but slow production |
| Hopper Dredge | Un-Suitable | Suitable but some problem w/ removal of well-graded beds | Var. with specific dredge... good for coarse to med.- fine tend to overflow as hopper fills ...cemented sands difficult | Can remove but difficult to retain in hopper... | No problem but lumps collect in hopper resulting in difficult dump. ..rotary cutter sometimes necessary |

It should be noted that while this list may not reflect absolutely all the available dredges (after all, there are few differences in cranes that sit on the land and those on barges), it does provide a fair idea of the types available and where they are located. The directory also provides additional technical information on each dredge listed and where to contact the company representatives.

Another factor which may be difficult to quantify is the skill and expertise of those who are to operate these dredges. Most of the information contained within the "Field Guide" is based on the notion that the machinery is being run by well-trained personnel. The most sophisticated and technologically advanced dredge perfectly matched to the project may look good on paper but could be an environmental (and economic) nightmare if not operated efficiently. Caution should be exercised before signing any contracts. Some knowledge of the history of the company and a few phone calls to previous customers will go a long way to assure that those who are paying for the project, whether the local, State or Federal taxpayer or private individual, are getting their money's worth and that no irreversible environmental damage will result from careless actions.

## DISPOSAL OPTIONS: PUTTING IT SOMEWHERE

There are really only three places to put dredged material: (1) on the land, (2) in the water, or (3) a combination thereof (i.e. intertidal areas). The many variations on these three basic themes are merely addressing the issues of "where" and "what else". The "where" question relates to the selection of a specific location; beach nourishment or nearshore berms, island or bulkhead containment, landfill cover or landscape enhancement. The "what else" deals with what is to be done with the sediment after it has been deposited; planting of submerged or marsh vegetation, agricultural crops or trees, park or recreational area enhancement, or hazard mitigation to name but a few. The ultimate goals of the reuse or disposal of dredged material are to: (1) find, if at all possible, a beneficial use for the material, and (2) assure that, at a minimum, the deposition of the material will result in no significant adverse short or long term, primary or secondary environmental or economic effects.

For ease of discussion, dredged material disposal has been broken down into three major categories:

| | |
|---|---|
| UPLAND | e.g. landfill cover<br>landscape enhancement<br>construction fill and materials |
| INTERTIDAL | e.g. artificial islands<br>shoreline modification<br>marsh creation |
| SUBTIDAL | e.g. aquatic habitat development<br>nearshore berms<br>deep ocean dumping |

What becomes apparent from even this short list of possibilities is that the disposal of dredged material, by necessity, requires a certain amount of creativity. While a part of this creative thinking is the result of compromise during the permit process, much of it is a reaction to the sheer waste of taking dredged material to sea and just dumping it. Nationwide, about 90% of this material is uncontaminated, and most of it is sand, a material that you normally pay good money for in other circumstances. While there are times when the costs of reuse of this material do not appear to be justified in the analysis of project costs and benefits, if this analysis is correctly done these instances are few.

### A. Upland Disposal

As the name implies, upland disposal is placement of dredged material wholly and totally in upland areas. This is generally used for smaller volumes of material and characterized by relatively high transportation costs and slightly different environmental testing requirements. Upland disposal can be either confined or unconfined depending on the character of the sediments.

Confined or contained upland disposal can be utilized for either contaminated or uncontaminated sediments. If contaminated, the area would be diked, capped (and perhaps even underlain) with an impervious material such as clay. The overall feasibility of this type of disposal has been demonstrated (Mallory and Nowrocki 1974, Krizek et al. 1976 cf Conner et al. 1979) although there may be problems with finding a suitable parcel of land for the facility which is near enough to the source to allow reasonable transportation costs and is acceptable to the community. Once the material has been placed in the containment area, the supernatant (water left after settling has occurred) requires some kind of treatment (see Wang et al. 1977 for detailed discussion of this topic). Construction costs are relatively high and there may be long-range problems with breaching of the containment area without adequate maintenance and monitoring. If the material is highly contaminated, this may be the only disposal option available.

Unconfined or uncontained upland disposal has generally been used for uncontaminated materials. Dredged material has been used for sanitary landfill cover, landscape enhancement, creating landforms, such as berms, or stabilizing erosional areas. It has been utilized as road bed fill for highway construction and even mixed into concrete and asphalt. These options may, in many instances, not be entirely appropriate (or acceptable to regulatory agencies).

The Department of Environmental Quality Engineering, Division of Water Pollution Control (DEQE-DWPC) has recently adopted additional policy guidelines regarding the upland disposal of dredged material which precludes many of these upland disposal possibilities when the material is marine in origin. Figure 3.1 is the categorization of dredged material proposed for an upland disposal site. Figure 3.2 is an excerpt from a policy memorandum from the DWPC detailing guidelines for upland disposal. Of particular concern is the salt, specifically its constituent ionic elements of sodium and chloride, contained within the marine or estuarine sediments. The introduction of salt into drinking water supplies renders it, for all intents and purposes, unpotable. In response to this potential threat to groundwater and surface water quality, these policies and specific standards have been adopted and are assumed to provide an appropriate level of protection. Specifically, 314 CMR 5.10 - Groundwater Discharge Permits - limit groundwater discharges to to 250 ppm total chlorides (Water Quality Standard for Surface and Groundwater) and 20 ppm Sodium (Drinking Water Standard). When the sodium concentration of the water/sediment dredged material slurry exceeds 20 ppm, upland disposal is prohibited. Given that marine waters have a significantly higher sodium concentration than that allowable under the standard, in most cases the question of possible upland disposal becomes moot.

### B. Intertidal Disposal

This includes all options which either displace or create intertidal areas. Environmentally, it may be one of the most difficult to justify in that it may displace habitat which supports a diverse and productive biological community. Transportation costs are, in general, significantly

FIGURE 3.1 - <u>DEQE CATEGORIZATION OF DREDGED MATERIALS FOR UPLAND DISPOSAL</u>

Regulatory categories pertaining to upland disposal of dredged material:

a. If PCB's exceed 50 ppm or if EP Toxicity Test (or TCLP, if required) limits are exceeded, the material is classified as hazardous waste and must go to a designated hazardous waste disposal site (none currently in Massachusetts).

b. If the limits in (a.) are not exceeded, the material is a solid waste and is subject to 310 CMR 19.00, "Disposal of Solid Wastes by Sanitary Landfill".

    1) If the sanitary landfill has an original site assignment from the local Board of Health which specifies dredged spoils, then the materials are allowed in the landfill.

    2) If the site assignment does not specify what wastes are acceptable in the sanitary landfill, only municipal wastes are allowed.

    3) Specific case by case Board of Health approval is needed for disposal of special wastes not designated in the site assignment for the landfill.

c. If the contaminants in the dredged material fall within the Type I or Type II Sludge categories (see excerpt from 314 CMR 32.00 below), DEQE follows a disposal policy (see Figure 3.2) in which DWPC with DSW (Div. of Solid Waste) concurrence designates the material as "clean fill" thus exempting the material from the solid waste disposal regulations referred to above. (However, note policy item 4, Fig. 3.2)

d. If the disposal site is on shore, as in the case of disposal behind a bulkhead, or if the site is very near the shore where the drainage or leachate is expected to return to the adjacent surface waters, DWPC permits dredged material disposal via the Water Quality Certificate without strict adherence to the upland disposal policy cited in (c.) above.

FIGURE 3.1 (CONTINUED)

| HEAVY METALS OR CHEMICALS | TYPE I MAX. CONC. (PPM DRY WT.) | TYPE II MAX. CONC. (PPM DRY WT.) |
|---|---|---|
| CADMIUM | 2 | 25 |
| LEAD | 300 | 1000 |
| NICKEL | 200 | 200 |
| ZINC | 2500 | 2500 |
| COPPER | 1000 | 1000 |
| CHROMIUM (total) | 1000 | 1000 |
| MERCURY | 10 | 10 |
| MOLYBDENUM | 10 | 10 |
| BORON (water soluble) | 300 | 300 |
| PCBs | 1-2 * | 10 |

* - for Type I Sludge or Septage, the maximum allowable concentrations of PCBs in soil conditioner [pursuant to 310 CMR 32.11(6)] is 1 ppm; in commercial fertilizer [pursuant as above], the maximum allowable concentration is 2 ppm.

FIGURE 3.2 - DEQE POLICY REGARDING UPLAND DISPOSAL OF DREDGED MATERIAL

The following is taken from a DEQE-DWPC memorandum establishing Departmental policy relating to the upland disposal of dredged material, dated 2 June, 1986.

Summary: DWPC currently regulates all dredging via the Water Quality Certificate. The recommended policy requires DWPC to obtain concurrence from the appropriate regional DEQE office regarding the disposal of the applicant's dredged material at a specific upland site after which such disposal will become an enforceable condition in the Water Quality Certificate. Only dredged materials which meet the Type I or Type II limits for contaminants as specified in 310 CMR 32.00 (Land Applications of Sludges) are subject to the (following) policy. As additional information becomes available, this policy will be revised to reflect any improvements in evaluation techniques.

1. The Water Quality Certificate will be issued following the DWPC's receipt of regional office concurrence with the proposed upland disposal. This document will contain conditions specifying (a) on-site dewatering of sediments and (b) disposal only at the site specified in the DWPC Certificate.

2. This policy will apply to sediments with contaminants which do not exceed Type II sludge limits as codified in 310 CMR 32.12. (a) Sediments meeting Type I sludge limits may be placed at an upland location. (b) Sediments meeting Type II sludge limits (but exceeding Type I limits) may be applied as daily cover at an approved landfill. Both disposal options are conditional on other provisions of this policy.

3. Dewatering of the sediments at the dredge site is required before the material is moved to an inland disposal site.

4. Marine sediments will be disposed of at near-shore sites unless they have been treated such that any remaining chlorides pose no threat to surface or ground waters.

5. DWPC will obtain physical and chemical data on the sediments to be dredged including: % sand, silt and clay; % volatile solids; % oil and grease; ppm metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc) and PCB's.

6. Analysis will be done on a composite of at least two sediment samples taken to the depth of the proposed dredging. (DWPC generally advises the applicant regarding the number and location of sample sites.)

7. EP Toxicity testing will not be required.

FIGURE 3.2 (CONTINUED)

8. DWPC will send to the regional DREE (Deputy Regional Environmental Engineer) responsible for Solid Waste the following: (a) The results of the physical and chemical analysis received in the application for Water Quality Certification, provided that the metals and PCB concentrations do not exceed those of Type II Sludge; and (b) a topographic map showing where the applicant proposes to dispose of the dredged sediment.

9. Review by DEQE regional personnel will result in concurrence with or a denial of the proposed disposal within 30 days.

10. The material receiving regional concurrence for disposal will be classified as clean fill rather than as waste and therefore it will not be subject to MGL Chapter 111, Section 150A and its site assignment requirements. The Water Quality Certificate shall contain a statement to this effect.

less than for upland options and may be somewhat less than costs associated with ocean disposal.

1. Island Creation: Only a possibility for larger projects due to the significant construction costs associated with such a facility. As an example, Hart-Miller Island in Maryland cost approximately $ 58,000,000 for the construction of a facility with the capacity of around 54,000,000 C.Y. The facility may also be somewhat difficult to site, given that a relatively large island placed in most harbors could have a significant adverse impact on the local current regime. As with upland disposal facilities, the island can be contained or uncontained.

A contained facility can be used for either contaminated or uncontaminated sediments and may be especially suitable for fine, unconsolidated silts. If contaminated materials are contained, the effluent from the dewatering process (i.e. the water separated from the slurry pumped or otherwise transported into the containment area) must be treated (anything from simple settling to adding flocculants to remove the very fine particles) before it is discharged back into the water surrounding the island. The structure must be engineered to withstand major gales and hurricanes, an additional reason for the high cost.

An uncontained island is usually made of clean sands in sandy environments. While piling sand in some harbor location would have some potential for changing the current flow, the effect may be less pronounced after the shape of the sand pile has been changed by the currents flowing around it. Once it has reached its "steady-state" configuration, planting may be necessary to enhance its value as habitat (widely used in the southeastern U.S. as bird nesting habitat) and stabilize the exposed portions of the island.

2. Shoreline Modification:

This option includes any confined or unconfined disposal adjacent to an existing shoreline. Like island creation, there may be environmental problems associated with resource areas (saltmarshes and tidal flats for example) which must be displaced to allow disposal. Transportation costs are, for the most part, lower than average.

Confined disposal on the shoreline can be appropriate for all sediments, whether contaminated or not. As with the island creation option, the effluent from the dewatering activity must be treated in some manner before it is discharged back to the water. This option includes an activity known as "reclamation dredging" which involves the creation of land for some water-dependent use, usually port facilities. As with all structural options, the cost of the containment structure will be a significant portion of the overall project cost.

Unconfined disposal includes the once popular option of dumping dredged material onto marshes. This "marsh reclamation" is largely responsible for the loss of saltmarsh in the Northeast and Mid-Atlantic

states and the once extensive mangrove swamps in Florida. While regulatory constraints have, except in rare instances, prohibited this form of dredged material disposal in many areas, there has been some research to suggest that in certain cases, the application of small amounts of dredged material may result in full recovery and even provide some benefit to the marsh (U.S. Army Waterways Experiment Station 1977, Lunz et al. 1978a and 1978b). However, this activity would require, under the existing regulatory framework in Massachusetts, special variances not easily acquired.

Beach nourishment is also considered a type of shoreline modification. The Massachusetts Coastal Zone Management Plan states, that if material is suitable, it should be used for beach nourishment. Generally, the material is suitable if it is clean sand and "compatible" with the existing material. This also involves the displacement of nearshore habitat, but the effects are usually temporary and the benefits from the its use as a non-structural alternative for shore protection are significant. In addition, there may also be benefits in habitat enhancement for rare, threatened and endangered species such as the piping plover.

The final major sub-option under shoreline modification is saltmarsh creation. There is an excellent discussion concerning this option in the U.S. Army Corps of Engineers (1986) "Beneficial Uses of Dredged Material" Engineering Manual, detailing not only site selection, but a great deal of "how-to" information. Generally, this option is suitable for only uncontaminated or slightly contaminated sediments. Questions have been raised as to how successful these projects have actually been and whether man-made marshes are functionally equivalent to natural ones (Race and Cristie 1982, Race 1985, Minello et al. 1987). Additional information regarding this option is available from the Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and Massachusetts Coastal Zone Management.

## C. SUB-TIDAL DISPOSAL

This encompasses all so-called "sub-aqueous" (underwater) disposal activity. It involves the displacement of habitat, and all the impacts associated with suspended sediment loading and contaminant release (discussed in Chapter 4). Materials must also meet federal, State, and local water quality standards (discussed in Chapter 5). Variations on this type of disposal relate to distance from shore.

Near-shore disposal involves the placement of material just seaward of beach systems. This allows the material to be carried onto the beach by the natural movement of sand as the beach builds and recedes with the seasons. While there is significant benefit from utilizing this option, it requires a substantial amount of site-specific information regarding the local bottom topography and current regime. Without this information, there is ample opportunity to place the material where it will rapidly shoal into the dredged channel or, in general, end up precisely where you don't want it.

Shallow ocean disposal (i.e. disposal of material on the continental shelf) is an option where material is taken to sea and dumped at designated dredged material disposal areas. In Massachusetts, one such area is the so-called "Foul Area Disposal Site" off Marblehead. In order to dispose of material at sites like the Foul Area, it must meet certain regulatory standards regarding levels of contamination, and be consistent with the Massachusetts Coastal Zone Management Plan. The Foul Area is currently receiving the bulk of the dredged material being generated on the coast north of Cape Cod. There has been some interest in the use of so called "sub-aqueous borrow pits", created in underwater sand and gravel mining operations, for disposal. There has also been some discussion and field testing of "capping" (O'Connor and O'Connor 1983, Brannon et al. 1985, Truitt 1986, Brannon et al. 1986), using cleaner materials to cover over more contaminated sediment, but its efficacy at the Foul Area is still an open question.

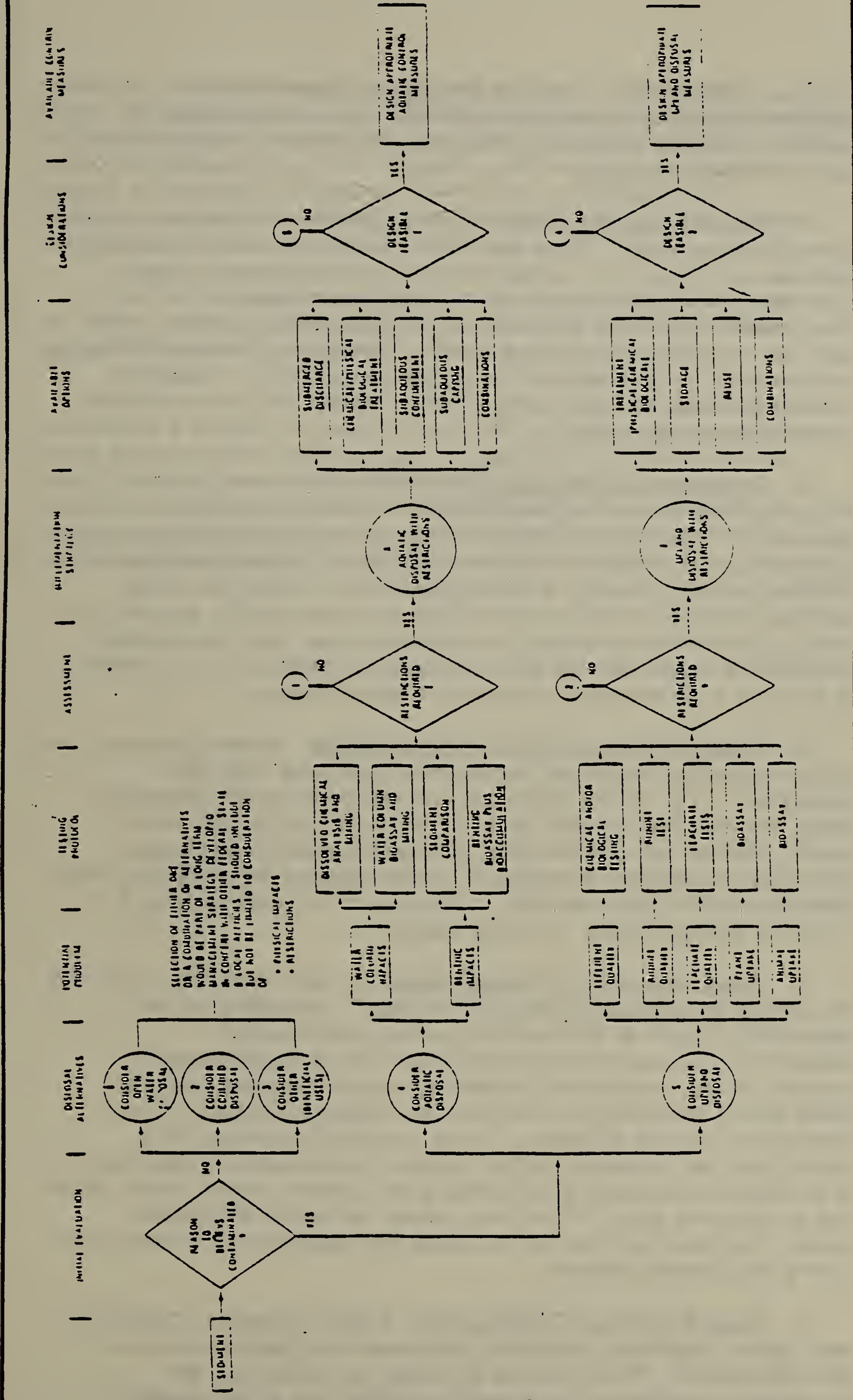
Deep ocean disposal (i.e. beyond the edge of continental shelf) has also been discussed (Grumman Ecosystems, Inc. 1975, Pequegnat et al. 1978 cf Conner et al. 1979) but rarely, if ever, done. This is especially true on the east coast, where the distance to the edge of the shelf is significant (and makes transportation costs prohibitive). In addition to the cost factors, it is probably not a good idea from an ecological standpoint, as there are indications that biological communities in the deep ocean could not deal with such a disturbance. Recovery, if it occurred at all, would be extremely slow.

Given the range of disposal options, the next task is to determine which one is most appropriate for a particular project. Francinques et al. (1985) suggest a scheme for deciding which disposal option is appropriate in a given situation based on physical/chemical/biological testing of the sediment and disposal area characteristics. Figure 3.3 depicts the management strategy advocated by the authors. Within the framework, the diamonds represent points of decision, a key part of the strategy in that this is where choices are made regarding how much risk as acceptable and how much you are willing to spend to attain those "risk-established" goals. Follow-up work by Waterways Experiment Station personnel, yet to be published, provides some recommendations for how to deal with the more difficult decisions (Richard Peddicord, personal communication). If there is one shortcoming of this strategy, it is that the decision is based on the results of the testing alone.

In contrast, Conner et al. (1979) suggests a more comprehensive decision-making framework which allows a broader range of questions to be addressed. The main points are summarized as follows.

A. Engineering Considerations: Primary Question- "Is is possible to implement this alternative using existing technologies?" Criteria, to be used depending on the option under analysis, include construction feasibility, transport feasibility, treatment required, time to implement, life expectancy of project, site stability, and long term maintenance and monitoring of the facility. Once the decision is made whether the

FIGURE 3.3 - Dredged Material Decisionmaking Framework
(Francinques et al. 1985)



criterion is appropriate, it must be determined if the criterion represents a limiting factor in all cases, some cases, or no cases. A factor is considered limiting if it cannot be implemented using available equipment and technology.

B. Economic Considerations: Primary Question- "Is the cost of this alternative reasonable?" Costs may include capital investment, annual operating costs, land cost, equipment needs, and inflationary impact. This part of the analysis is not an easy task. Most times, a "cost/benefit" analysis is used but it is difficult to place a dollar value on environmental costs and benefits. Ultimately, "reasonable" may be determined by how much of the project budget is left to spend on disposal after the dredging expenses are excluded. This is not, however, a form of economic analysis.

C. Environmental Considerations: Primary Question- "Are substantial negative environmental effects associated with this alternative?" The range of criteria to be considered include substrate compatibility, persistence of impacts, alteration of existing conditions, shellfish impacts, impacts on faunal reproduction, impacts to faunal movement and migration, toxicity effects, and water quality impacts. In order to be considered limiting, the alternative must have the potential to produce a permanent and severe detrimental impact, direct or indirect, to a unique or commercially valuable biological resource.

D. Public Health and Welfare Considerations: Primary Question- "Are substantial public health and welfare risks associated with this alternative?" The criteria for evaluation, depending on the alternative under consideration, include effects on air quality, effects on water quality (surface and groundwater), proximity to public water supply, public safety, dispersal of pathogens, public exposure to carcinogens, and contamination of food resources. An alternative is found limiting if it results in substantial risk to public health.

E. Social Acceptability Considerations: Primary Question- "How will the project be received by the public at large?" Depending on the alternative, criteria to be considered include general social acceptability, acceptability to federal, state and local governmental agencies, energy consumption, reduction in energy supplies, limits to other uses of the resources, effects on the employment climate, land availability, and size of project. While the public perception of a project may not, ultimately, affect whether an alternative is selected, it is of primary importance in determining the political climate within which the project must exist. While these criteria are rather difficult to assess, it is important that they be taken into consideration at some time during the planning process.

F. Legal/Regulatory Considerations: Primary Question- "Are there any legal or regulatory constraints that would limit implementation of this alternative?" While this was listed last by Conner and his co-workers, it should be considered first before any of the detailed

ecological, socio-economic or engineering assessment is undertaken. Indeed, Massachusetts has, within DEQE regulations pertaining to dredging and water quality (314 CMR 9.00), provided an example of this type of regulatory guidance (Fig. 3.4). In order to evaluate the alternatives in light of the regulatory framework, see Chapter 5 dealing with the regulatory agencies and Chapter 6 for a discussion of the environmental testing requirements.

While the entire process as described above may be a bit excessive for smaller projects, the major issues should all be considered to the appropriate level of detail given the character of the project.

If there is one "take home message" in this chapter, it is that the selection of a disposal alternative should not be based solely on which site is typically used. It is far more appropriate to carefully examine a suite of disposal options, selecting the alternative which is the most environmentally and economically acceptable rather than the most convenient. This is an area, especially in regard to contaminated sediments, where creativity is a vital aspect of the process.

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Dredging Technologies
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Environmental Impacts
Regulatory Framework
Environmental Testing
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## ENVIRONMENTAL EFFECTS OF DREDGING:

While the act of dredging and dredged material disposal may seem, from our vantage point, an economic necessity, from the point of view of the organisms that call the sediment "home", the physical removal of sediment, the introduction of massive quantities of suspended sediment into the system, the release of toxic substances from the sediments, all could appear as rather significant events to the unfortunate quahog or oyster being sucked into the draghead of a hopper dredge. The potential environmental impacts include physical, chemical, and biological alterations in estuaries and coastal waters which, depending on a complex set of conditions, may have little lasting effect or significantly and irreparably alter the system. The goal here is to minimize adverse impacts through proper planning and execution based on knowing where the potential environmental problems are and how to avoid them..

What follows is a detailed discussion of the biological, chemical, and physical effects of dredging and dredged material disposal which has been reported in the scientific literature, review articles from engineering and technical sources, and other relevant documents. There is a sizeable body of knowledge surrounding this subject, with some of the earliest works appearing in the late 1930's in engineering journals and federal and state agency bulletins. The majority of the research regarding the environmental effects of dredging appeared in the 1970's. In recent years, the review papers on the environmental effects of dredging have, for the most part, been replaced by more specific discussions of topics like contaminant remobilization and bioavailability/bioconcentration. As is the case with most scientific disciplines, as we acquire more general knowledge about a particular subject, our questions become more focused and the answers more complex.

Each section of this chapter is preceded by a summary of the key information contained therein, and provides page references for each of the points of interest so that the more detailed information in the text is readily accessible. These summaries contain very general statements regarding information essential to understanding the potential impacts of dredging operations. Summary statements have been greatly simplified in the interests of highlighting the most important concepts or "order of magnitude" estimates of important environmental parameters and require reading the more detailed information in the text reference to understand the scientific context from which it is taken. Specific references to the original work drawn upon for the purposes of this review have been included, with full citations, in the Bibliography (see Chapter 8). The information has been presented in this way so that, no matter what your particular interest is, the necessary level of detail will be available.

The reasons for our collective interest in the environmental impacts of dredging and dredged material disposal goes well beyond the purely scientific motivations of looking at an ecosystem undergoing a significant perturbation. What piques our interest and motivates us to learn more is that the potential threat to public health, safety, and welfare arising

from the significant adverse environmental impacts associated with improperly planned and executed dredging projects, is, in large part, the rationale for regulation. If there was no possibility of a potential adverse environmental impact, there would be little reason to regulate, other than, perhaps, prohibiting hazards to navigation. Another reason for our interest touches every citizen of the Commonwealth in a very direct way. Almost all dredging projects involve lands owned by the Commonwealth of Massachusetts and held in trust for its citizens. Given that the governmental agencies entrusted with the stewardship of these so-called "public trust" lands have the responsibility of effective protection and management, the preservation of the environmental quality of these "lands", and the waters above them, must be a major part of their effort.

## A: SEDIMENT RESUSPENSION AND TURBIDITY

### SECTION SUMMARY

- the volume of sediment resuspended varies widely depending on the type of dredge and sediment characteristics (p. 4-2)
- average suspended sediment concentrations (mg/l) (p. 4-3)
    - background levels 1-10
    - active dredge site 200-800
    - natural storm event 1000-1500
    - slurry pumped by hydraulic dredge 1200
- area of greatest potential impact...within 300 M of dredge site (p. 4-3)
- distance to return to background levels of turbidity...500-700 M (0-1000 M reported in literature) (p. 4-3)
- areal extent of plume...4-5 sq. km (2-3 sq. mi.) working in fine sediments (p. 4-3)
- dredging may permanently increase ambient turbidity (p. 4-3)

Most of the direct impacts to the ecosystem are caused by turbidity and siltation. All dredges resuspend sediment either directly or indirectly. The volume of sediment resuspended depends on the type of dredge being used, the skill of the operator, and sediment characteristics. Bohlen et al. (1979) investigated the magnitude and character of this dredge-induced resuspension of sediments and found that,

for a large clamshell dredge, suspended sediment loadings were on the order of 200-400 mg/l adjacent to the dredge site, exceeding background levels by approximately two orders of magnitude. Around 700 M downstream of the site, suspended sediment concentrations returned to background levels. The authors suggest that while sediment characteristics may alter the outcome, the major turbidity-related impacts are restricted to within 300 M of the source of resuspension. May (1973) took a less conservative stance in concluding that beyond around 33 M, turbidity did not exceed natural levels. Windom (1976), taking the extreme position, reported that no elevated levels of suspended sediment were observed during maintenance dredging through a salt marsh estuary. Turbidity plumes can be significantly larger. While Peddicord (1985) suggests, in general, that suspended sediment tends to dilute to "acceptable levels" within 1000 M, turbidity plumes of 4-5 $km^2$ have been reported in the literature (Chesapeake Biological Laboratory 1970 cf NMFS 1980). Lunz (1985) also points out that the highest concentrations of suspended sediment are restricted, at least in most hydraulic dredging operations, to within 2 meters of the bottom. What these estimates clearly indicate is that each combination of current regime and sediment characteristics will produce a somewhat different turbidity plume. Site specific information is vital to making accurate general statements about a specific situation.

Siltation impacts, however, may be significant over a greater area. Finer silts, clays and colloidal fractions remain suspended for longer periods and can be transported great distances from the dredge site (Mackin 1961, Hellier and Kornicker 1962, Oertel 1975, Bohlen et al. 1979). This is especially important where the sediments are contaminated. Simon and Dyer (1972) observed a silt plume which covered approximately five square kilometers of natural sediment surface, resulting from a shell dredging operation in Tampa Bay, Florida. This plume significantly changed the character of the surficial sediments. Siltation is also responsible for increasing ambient turbidity, allowing the now unconsolidated, finer surficial materials to be resuspended more easily by waves and currents (Jones 1981).

## B. BIOLOGICAL IMPACTS

### SECTION SUMMARY: INDIRECT IMPACTS

- decrease in depth light can penetrate water column (p. 4-4)
- decreases photosynthetic rate of primary producers (phyto-plankton, submerged aquatic vegetation - eelgrass, benthic diatoms (pp. 4-4, 4-5)
- increases water temperature (p. 4-5)

SECTION SUMMARY: INDIRECT IMPACTS (CONTINUED)

- decreases dissolved oxygen (DO) concentrations (pp. 4-4, 4-5)
- increases availability of nutrients (p. 4-5)
- may decrease pH under certain circumstances (p. 4-5)
- most of these parameters are interrelated...e.g. decrease in photosynthetic activity may be counterbalanced by increases in the availability of nutrients...increases in temperature results in a decrease in the solubility of oxygen...and may result in significant impacts to the biota

The impacts associated with this increase in suspended sediment can be broken down into two broad categories, alterations in water quality and primary productivity of the system and direct effects on organisms. With regard to the impacts related to primary productivity, as suspended sediment loading increases, the depth of penetration of light decreases. This decrease in light penetration may have the effect of decreasing the photosynthetic rate of phytoplankton thereby decreasing primary production. Sherk et al. (1975) reported a 50-90% decrease in the carbon assimilation capacity of four species of phytoplankton with an increase in suspended sediment/decrease in light intensity. This may cause the compensation depth (i.e. that depth where production exceeds respiration) to move toward the surface (Sherk 1971). If in shallow water where the photic zone (i.e. light penetration depth) extends to the bottom, photosynthetic rates of submerged aquatic vegetation may decrease leading to a possible reduction in the size or density of the bed (Simon and Dyer 1972). These same authors also suggest that further decreases in the size of the phytoplankton population may result from phytoplankters being incorporated into flocs which eventually settle to the bottom, exacerbating the decrease in primary productivity. Benthic diatoms and other microflora, an extremely important, though widely ignored, component of many coastal and estuarine systems, can also experience a significant decrease in primary production (Taylor and Saloman 1968). As an example, Sheaffer (1984) found that a pulse of fine sediment which formed a thin blanket over a sandflat resulted in a 6.5 X decrease in net primary productivity. While benthic diatoms undergo a diurnal vertical migration of a few millimeters, if the siltation exceeds this distance or the sediment character changes significantly (e.g. reduction in size of the interstitial spaces), this very important component of the system could be, at least temporarily, lost.

This inhibition of photosynthetic activity and associated decrease in primary productivity may be counterbalanced by a release of nutrients with

the resuspension of sediments. Sediments, especially those which are high in organic content, are storehouses for nutrients such as nitrates, nitrates and phosphorous compounds. The release of these compounds may stimulate production by supplying limiting nutrients to the system. Morton (1977) cited examples of this counterbalance phenomenon where primary production was not significantly affected, and suggests that where systems are nutrient limited, primary productivity may not be affected.

Another effect of the resuspension of bottom sediments is the potential for changes in temperature, dissolved oxygen and pH. As turbidity increases, more and more light is absorbed rather than reflected (Everhardt and Duchrow 1970 cf Johnston 1981). This temporary increase in temperature may produce direct effects on the biota of the system, which will be discussed later in this section, and change the solubility of oxygen. The dissolved oxygen (DO) concentration in the water column is likely to be significantly affected by the resuspension of anoxic sediments. Frankenberg and Westerfield (1968) cited in Rees (1980) calculate that some dredged materials require 535 times their own volume of oxygen for complete oxidation. Brown and Clark (1968) found DO concentrations near active dredging sites to be 18-82% below normal and Simon and Dyer (1972) achieved remarkably similar results (16-83% below normal) with an 8 X increase in biological oxygen demand (BOD). Windom (1976), however, reported an increase in DO concentration which was attributed to enhanced primary production due to nutrient release. This change in DO is especially critical in warmer months when DO concentrations are usually lower (Sherk 1971). While short periods of low DO concentrations (though short of anoxia) are usually not a problem in most estuaries and coastal waters (Krenkel _et al_. 1976), cumulative impacts may result if the body of water in question is also the receiving waters for a wastewater effluent discharge or from some other point/non-point nutrient source. Morton (1977) has suggested that although dredged material may be oxygen-depleted, this oxygen demand may not be much of a concern in areas with a high degree of flushing. A number of other studies (Marshall 1968, Shelton 1971, Pearce 1972, Hopkins 1972, Rees 1980, Van Der Veer _et al_. 1985, Lunz 1985) provide support for this observation. By way of summary, Morton (1976) suggests that factors which may alter the impact of changes in DO concentrations include, 1) the stimulation or inhibition of primary production, 2) change in the sediment's physical arrangement (deposited to suspended), 3) the sediment's redox potential (i.e. oxygen concentration of the sediments being dredged) 4) the sediment's organic content, 5) the sediment's chemical composition, 6) handling of the material during the dredging and disposal operations, and 7) the degree of flushing at the (dredging and) disposal site.

High turbidity has also been linked to increases in carbon dioxide concentrations (EPA 1976) which may act to lower the pH of the waters, especially if the suspended sediments are not calcareous (i.e. low buffering capacity).

## SECTION SUMMARY: DIRECT EFFECTS ON INDIVIDUAL BENTHIC ORGANISMS

- benthic organisms [bottom dwelling-infaunal (live in sediment) or epifaunal (live on sediment surface), motile (moves around) or sessile (stays in one place), filter feeders (feed on suspended material) or deposit feeders (feed directly on the sediment)] have the greatest potential for significant impact (pp. 4-6, 4-7, 4-8)

- early life stages (larvae, juveniles) usually more sensitive to adverse impacts (pp. 4-6, 4-7, 4-8)

- effects can be lethal (cause mortality...pp. 4-6, 4-7) or sub-lethal (cause deleterious change in growth and/or reproduction...pp. 4-7, 4-8)

- motile epifauna (crabs, lobsters, etc.) usually move away from areas of greatest impact (p. 4-8)

- moderate suspended sediment concentrations may be beneficial to certain organisms in appropriate circumstances (p. 4-8)

- typical direct impacts:

  - entrainment (organism is picked up by the dredge with sediments being removed...p. 4-6)
  - burial (p. 4-7)
  - impaired respiration or feeding behaviors (pp. 4-6, 4-7)
  - abrasion and clogging of gill filaments (p. 4-7)
  - retarded egg development and reduced egg buoyancy (p. 4-7)
  - reduced survival and/or growth of larvae (and other sensitive life stages...pp. 4-7, 4-8)

Direct effects to organisms is the second major category of impacts on the biota. The literature dealing with the environmental effects of suspended sediment and siltation on individuals, populations, and communities comes from dredging-related studies, investigations into animal/sediment interaction, and work involving the role of disturbance or perturbations of biotic communities. From the results of the many studies that have been undertaken to elucidate the relationship between disturbance and community structure, a pattern of types of impacts resulting from dredging activity has developed. Windom (1976) suggests a framework which includes: 1) habitat disruption, 2) inhibition or stimulation due to water quality changes, 3) interference with migration, 4) entrainment, and 5) cropping or extermination. NMFS (1980) suggests that "habitat disruption can occur in the dredging site due to the removal of bottom sediment. Disruption of habitat may also occur when productive

bottom areas are used as spoil disposal sites. Water quality changes may result in inhibition of growth and reproduction of some organisms. Seasonal migration of some organisms, such as anadromous fishes, may be disrupted by dredging operations in river or harbor areas. The movement of larval or juvenile forms of marine organisms may be affected as well as many species which molt or become inactive, such as lobsters. Mortality has occurred from entrainment of suspended gametes or larvae, burial and suffocation of molluscan shellfish, mechanical injury to burrowed, overwintering organisms too lethargic to avoid the cutterhead or clamshell, are all suspect of physical dredging impacts."

The effects of dredging on benthic organisms has been the most widely studied aspect within this area of investigation, especially as it relates to sessile organisms and commercially important species. While not all of this literature deals directly with impacts associated with dredging, much of it relates to the effects of suspended sediment, siltation, release of toxic contaminants, and the response of individual benthic organisms and communities to physical disturbance. Regarding the potential impacts to individual organisms, both lethal and sub-lethal effects have been observed. Mortality can result from entrainment (e.g. being picked up by the dredge with the sediment being removed) or through burial by resuspended sediment or dredged material deposition. Survival of such mechanical stress is broadly variable (NMFS 1980). Direct burial can be, but is not always, a significant source of mortality, especially to sessile or attached forms such as mussels or oysters (Saila _et_ _al_. 1972, Rose 1973, Collinson and Rees 1978). Nichols _et_ _al_. (1978) found, in _in-situ_ burial experiments in Buzzards Bay, that most organisms common to this type of soft-bottom community could escape a burial of 5-10 cm, but none attempted to escape when placed under 30 cm of sediment. The authors further suggest that the bulk density of the material and burial depth (so-called "overburden stress") act together to limit initiation of an escape response. When the overburden sediments are anoxic, some smaller organisms are more sensitive to burial because they are unable to burrow out before they suffocate (Hirsch _et_ _al_. 1978). Escape time for many of these organisms is dependent on whether they have physiological strategies for dealing with low oxygen conditions (sensu Salia _et_ _al_. 1972). Ingle (1952) observed insignificant adult oyster mortality within 200 M of an active dredge. However, Godcharles (1971) found that all of the oysters within the vicinity of a commercial hydraulic clam dredge died, and that a significant number of within 8-9 M also died. In addition to adult mortality, larval and juvenile life stages are also very sensitive to burial. Godcharles (1971) further suggested that a possibility of oyster spat mortality existed within 25 M of an operating dredge. This potential of high mortality from burial is especially true in warmer months (Brown and Clark 1968), when the suspended sediment effects are combined with the effects of elevated temperatures and low DO.

If burial from deposition of dredged material or settling suspended sediment does not prove lethal, the so-called "sub-lethal effects" may be significant. Sherk (1971) suggests that suspended sediment may clog or abrade gill filaments, impair respiration and feeding behaviors, reduce

egg buoyancy, retard egg development, and reduce growth and survival of larvae in filter feeders (see also Kaplan et al. 1975). Many different kinds of larvae are sensitive to high suspended sediment concentrations (Rosenberg 1977) especially crustacean larvae and eggs (Stern and Stickle 1978). If a given species or life stage of that species is particularly sensitive to a specific size fraction (e.g. silts which have high dispersion potential), potential effects can be far field (sensu Taylor and Saloman 1968). As an example, lobster larvae are particularly sensitive to quartz particles in the range of 30-55 um; when subjected to this size fraction, significant mortality or sub-lethal effects can be expected to be exhibited at any location within the turbidity plume (Cobb 1972 cf Johnston 1981). Lunz (1938, 1942, cf Morton 1977) observed that dredging had no effect on the development of reproductive tissue, spawning, or the number of spat settling in the area of a dredging operation. Davis (1960) found that eggs of the clam Mercenaria, in response to increasing suspended sediment concentrations, were impaired in their development, and that growth of the larvae of the same species was inhibited or mortality resulted from relatively high concentrations (1-4 g/l) of suspended sediment. Loosanoff (1961) observed similar results for Mercenaria and provided data for oysters. While the effects on larvae and other early life stages are usually deleterious, the impacts can be highly variable depending in large part on the proximity to the highest concentrations of suspended sediment.

A number of authors have made the suggestion that moderate suspended sediment concentrations (e.g. an order or two of magnitude) have no lasting impact on filter feeding organisms. Taking this one step further, even high concentrations may not be a problem if exposure is limited (Saila et al. 1972). Indeed, exposure to a certain amount of suspended sediment may be beneficial, increasing the food resource available to the organism (sensu Rhoads et al. 1975). Kiorboe et al. (1981) observed that the suspended bottom material was a secondary food source for the mussel Mytilus edulis and that, all else being equal, silt in low concentrations (i.e. within an order of magnitude of background levels) enhanced both growth and clearance rates. For infaunal deposit feeders, this siltation represents a significant food resource which may be either exploited by the existing community or provide new substrate for colonizing species (McCall, 1977). Another group, the motile epifauna (e.g. crabs, lobsters, etc.), seems to fare much better than sessile forms in "pulse" type events, being able to move away from the area of greatest suspended sediment concentrations.

SECTION SUMMARY: RECOVERY OF DREDGE/DISPOSAL SITES

- difficult to assess impacts due to natural variability of community structure (e.g. seasonal population fluctuations) and similarity of response to natural disturbances (e.g. storm generated waves and tides...p. 4-9)

## SECTION SUMMARY: RECOVERY OF DREDGE/DISPOSAL SITES (CONTINUED)

- changes in benthic community structure considered best "yard-stick" for determining if a significant adverse impact has, or is likely to, occur (p. 4-9)

- rate of recovery depends, to a large extent, on: 1) how the organisms present deal with the direct and indirect effects discussed above, 2) the availability of a "seed stock" of larvae (or adult colonizers), and 3) the extent of the changes resulting from dredging (pp. 4-9, 4-10, 4-11)

- the pattern of recovery depends on where the colonizing organisms come from...either adults from sediments slumping into dredged area or direct larval settlement (pp. 4-10, 4-11)

- recovery times vary greatly...from less than a year to more than 15 years (pp. 4-10, 4-11)

Changes in benthic community structure as a result of dredging or dredging-like perturbations has been widely studied, especially as it relates to the recovery of recently dredged areas. The characterization of this recovery is the central question. Livingston (1982) describes the variability of biological systems over time as follows: "Temporal variability (of biological systems)...is complex since, at any given instant, a natural system represents a composite series of different temporal sequences of varying periods superimposed over one another as a result of an almost infinite number of cause-and-effect reactions. The problem in finding order of causality is heightened by the fact that these overlapping cycles may differ along habitat and microhabitat gradients and at different levels of biological organization. Consequently, the term 'background noise' becomes a euphemism for our inability to determine the temporal or sequential modes of system function". Because many of the environmental consequences of dredging are quite similar to those resulting from natural events, it is very often difficult, given the magnitude of the "background noise" in coastal and estuarine systems, to separate this natural variation from the impacts directly attributable to the act of dredging. The types of disturbances which may result in similar impacts include a range of perturbations from deep erosion and resuspension of sediments caused by storm-generated waves and tides to simply seasonal or other temporal changes in community structure caused by variation in water temperature or food supply. Johnson (1973) and McCall (1977) describe the sediment surface as a "temporal mosaic; different parts of a habitat disturbed at different times contain different faunas". "The community", continues Johnson, "is conceived of as continually varying in response to a history of disturbance. In this view, the community is a collection of relics [and recoveries] of former

disasters". One of Johnson's "former disasters" may have been a dredging project.

Keeping in mind the limitations as discussed in the foregoing discussion, benthic community response to a disturbance such as dredging may be the best way to determine whether a particular project has had a significant adverse impact. If you review enough of these analyses, a pattern of response emerges which may allow a qualified prediction of potential impacts. Fortunately, there have been many such studies undertaken and a wealth of information from which to draw a few "order of magnitude" conclusions.

The collective fate of the constituents of the benthic community hinges on the direct impacts to organisms discussed earlier. Both the actual dredge site and the disposal site are of interest in the recovery process. The disposal site is especially important in that if the material is being placed in an intertidal or subtidal area, the existing community is being sacrificed. NMFS (1980) suggests that the two most important factors determining whether recolonization of these areas occurs are 1) the relationship between the benthic organisms and the sediments, and 2) whether the adjacent undisturbed community is able to provide a pool of replacement organisms capable of recolonizing the site by adult migration or larval recolonization.

The first factor relates to whether the organisms available for recolonization find the substrate "suitable". If the sediment is so unconsolidated that larvae cannot establish themselves (e.g. effectively burrow or build tubes) or if it is of a grain size too large or small that the deposit feeders cannot ingest it, recolonization will either not occur or it will be extremely slow (sensu McGrorty and Reading 1984). Generally, recovery is enhanced if the character of the sediment is unchanged by the dredging (Taylor and Saloman 1968, Simon and Dyer 1972, Stickney and Perlmutter 1975). This is also true of the survivorship within the community buried at the disposal site. Lunz and Clarke (1985) suggest that organisms survive best if buried in the sediment type they are adapted to; as an example, animals usually found in sand seem better adapted to survive burial in sand than in mud. In addition to changes in bulk sediment characteristics, removal of things such as shell fragments may cause the loss of certain species which use those fragments as refuges from predation or require hard surfaces as attachment sites (Barnard and Reish 1959).

Another important factor in recovery is the current regime at the dredge site. It is not the direct effect of the currents that is of special interest but the effect the currents have on sediments. Van Der Veer et al. (1985), in an investigation of various dredging sites in the Dutch Wadden Sea, found that recovery in channels with strong tidal currents was significantly more rapid than in subtidal areas with low tidal stream velocities, such as tidal watersheds. Dredging in borrow pits on tidal flats was found to be significantly slower, falling short of complete recovery within the 15 year duration of the study. The authors

attribute this variation to differences in mode or recolonization (i.e. in-migration of adults in high current channels vs. larval recruitment in low current channels) and postulate that the slowness of the borrow pit recovery is due, in large part, to the periodic anoxia caused decomposing detrital material collecting in the pit, stagnation of the watermass within the pit, and the unsuitability of the material for settling larvae. The results of this study, as applied to the project planning aspects of dredging, provide important scientific evidence supporting the idea that dredging dead-end canals and isolated coves without proper tidal exchange should be prohibited.

Examples of recolonization rates for dredged channels abound in the literature (for specific examples, see Simon and Dyer 1972, Kaplan et al. 1975, Stickney and Perlmutter 1975, Rosenberg 1977, Oliver et al. 1977, Conner and Simon 1979, Swartz et al. 1980, Jones and Candy 1981, Poiner and Kennedy 1984, Van Der Veer et al. 1985). The pattern of a "typical" recovery would be that, after the area is dredged, the "first wave" of colonizers would be the so-called "opportunistic species", those species which have acquired certain life history characteristics which allow them to exploit patches of sediment which do not, for one reason or another, contain other organisms. They are predominately deposit feeders and produce a large number of planktonic larvae. Their life cycle can be characterized as " boom and bust"; exponential growth of the population until resources become limited, then a catastrophic die-off. These are mostly smaller polychaetes and crustaceans. These species, with time, are gradually replaced with other species which require a relatively stable environment, are longer-lived and larger, in general, than the opportunists. These organisms are more likely to be filter feeders and typically produce fewer larvae with a much higher survival rate than the early colonists. Organisms in this category include most of the commercially important shellfish species. What is important here is that, if any permanent change in environmental conditions occurs, the expected response will be a change in the benthic community structure. If current velocities change, if sediment characteristics are different, if a source of larvae or adult migrants is cut off, what was there may not be there afterwards.

The rate of recovery will be contingent on the severity of the change in environmental conditions. Good tidal flushing seems to promote recovery (sensu Johnston 1981) as it supplies larvae for colonization and keeps the DO and nutrient levels relatively constant. Lunz and Clarke (1985) have suggested that if the community is "accustomed to" physical disturbance, it will be far less likely to be affected by dredging. Termed "community resilience" by Oliver et al. (1977) and "disturbance climate" by Lunz and Clarke (1985), this factor may be quite useful in determining the level of protection a particular site will require. If the water is frequently turbid, and the concentration of suspended sediment is similar to that which would be resuspended during a dredging operation, it is likely that the community found at the site will be able to handle the sediment load. This is not an unusual situation. Natural storm events producing wind-driven currents will, in certain instances,

produce suspended sediment concentrations which are three orders of magnitude greater than background levels. Hayes (1978) reports suspended sediment concentrations at the mouth of the Susquehanna River in the uppermost reaches of the Chesapeake Bay on the order of 10,000 mg/l after the passage of a hurricane. Given the usually localized effects of dredging and the extensive area that can be affected by a severe storm, questions of relative impact become very important. As a general rule, it is important to know what the existing conditions are with respect to natural levels of suspended sediment, both in calm weather and during storm events.

SECTION SUMMARY: FINFISH IMPACTS

- lethal and sub-lethal impacts...though lethal effects are more rare due to organisms' ability to avoid areas of high suspended sediment concentration (pp. 4-12, 4-13)

- high suspended sediment concentrations can have a variety of physiological and behavioral effects (pp. 4-12, 4-13)

    - reduction in swimming activity
    - increases in "coughing" and gill scraping behaviors
    - changes in blood gas chemistry
    - reductions in stored metabolic reserves
    - impairment of feeding activity
    - abrasion of body surfaces...leading to high potential for parasitic invasion and bacterial/viral/fungal infections

- spawning migrations may be affected...thresholds are species-specific and most are within the range of reported levels from dredging operations (p. 4-13)

- bottom dwelling species appear to be more tolerant than filter feeding pelagic fish...juveniles more sensitive than adults...reproductive success can be affected (p. 4-13)

The benthic component of the system is not the only one potentially affected by dredging operations. Finfish impacts have also been reasonably studied. Bouma (1976) observed that certain fish may be affected by a decrease in visibility, making feeding difficult. Along these same lines, LaRoe (1977) points out that fish which find their food by "smell" (i.e. by sensing certain chemical cues) may also find feeding difficult. As speculation, this may also have an affect on migratory species which may be using olfactory (chemical) cues to find its way to the appropriate run. While finfish are relatively motile and can, like crabs and lobsters, move away from areas with the unacceptably high

suspended sediment concentrations, if caught in such conditions, abrasion of the body surfaces can result, removing the mucous coating and increasing potential for invasion of parasites and disease (Everhart and Duchrow 1970 cf Johnston 1981). EPA (1976) states that very high suspended sediment concentrations can suffocate fish by clogging gill filaments and filling the opercular cavity. The authors further report that fish near active dredge sites can exhibit marked reductions in general swimming activity, social dominance patterns are modified, and fish are often engaged in "coughing" and gill scraping behaviors.

Mortality of finfish directly attributable to dredging is rarely seen, with the possible exception of the hapless fish entrained with the material being removed. The short-term exposure resulting from dredging seems to produce few effects. Chesapeake Biological Laboratory (1970 cf NMFS 1980) reports that lethal effects were not observed in the 44 species of fish tested in-situ near an active dredge site. Stickney (1973) observed no finfish mortality during a hydraulic dredging operation. Though the fish avoided areas of highest suspended sediment concentration, they were observed to remain nearby, presumably to take advantage of the increased food supply (i.e. benthic invertebrates being entrained and discharged by the dredge). Ingle (1952) observed similar results with regard to finfish mortality.

Laboratory studies dealing with suspended sediment tolerances of finfish have also been undertaken. Sherk et al. (1974) looked at lethal and sub-lethal effects of various concentrations of suspended sediments and found results similar to those reported earlier. If concentrations were high enough and exposures of sufficient duration, gill clogging would eventually lead to the fish's demise. Sub-lethal effects observed, in addition to those listed above, include changes in blood gas chemistry, packing of the gut with large quantities of ingested solids and reductions in stored metabolic reserves. General conclusions were that bottom dwelling species are most tolerant and filter-feeding fish least, and juvenile forms are more sensitive than adults. Reproduction may also be affected, behaviors may be altered, eggs could be destroyed, and gamete viability and egg buoyancy affected (Huet 1965 cf Morton 1977).

Spawning migrations may also be significantly affected. Radtke and Turner (1967) observed that the upstream migration of striped bass was inhibited by the presence of suspended sediment concentrations of greater than 350 ppm and found that an even lower concentration was required to inhibit spawning activity. Ingle et al. (1955 cf Morton 1977) found that finfish avoided tanks with high turbidity and Bell (1973) reported that silt levels above 4000 ppm prevents salmonids from migrating.

As stated in Cheaspeake Biological Laboratory (1970 cf NMFS 1980), The assessment of impacts of dredging and dumping on fish is complicated by their motility and general patchy distribution. Although one can estimate the abundance of fish at the time of sampling, there is no way of measuring changes in abundance once they have moved away from the sampling area. Given that fish can usually avoid the worst of the effects, it is

doubtful that, except in the case of reproductive-related impacts, any significant impact will occur. With regard to questions of migration and egg viability, etc., it is important to have adequate information to assess the potential impacts. NMFS (1980), from which a portion of this section is taken, is an excellent source for species-specific information. Site-specific information is, as always, vital to the planning process.

## C. EFFECTS RELATED TO SEDIMENT CHEMISTRY AND CONTAMINANT RELEASE:

SECTION SUMMARY

- importance of understanding changes in sediment chemistry lies in how changes affect contaminant release (pp. 4-14, 4-15)

- once released (remobilized), toxic material can be taken up by organisms, sometimes concentrating the contaminant, and transferred up the food chain, potentially to man (p. 4-15)

- no simple direct relationship exists between bulk chemical properties (concentrations of toxic substances) of sediments and potential deleterious impacts to environmental quality (p. 4-15)

- finer (silt/clay) sediments with high organic content have greatest potential for causing adverse impacts (p. 4-15)

- remobilization of toxic substances can directly cause mass mortality in both finfish and invertebrates (p. 4-15)

The physical and chemical characteristics of sediments are such that they tend to bind contaminants and other toxic compounds which are discharged into the aquatic environment. The consequences of this simple chemical activity are highly significant with respect to dredging and dredged material disposal. When sediment containing toxic materials is dug up and removed, the opportunity for remobilization is greatly increased.

The types of toxic compounds sometimes associated with dredged material are the same as those which are discharged in domestic and industrial wastes (Wang and Leonard 1976), a fact that should surprise no one given that these discharges are, in most cases, the source of this contamination. The types of substances, toxic or otherwise, which can be released into the water column include hydrogen sulfide, methane, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), organic acids, ketones, aldehydes, heavy metals, and pesticides (EPA

1976), as well as nutrients such as nitrates and phosphates (Morton 1976). This release or remobilization into the water column results from two major reasons, 1) dredged sediments are, for the most part, anoxic, and 2) although chemical constituents on the surface of the sediments are, in large part, in dynamic equilibrium with the overlying waters, those deeper in the sediments are not (Morton 1976). Without going into great detail (see Morton 1976, Gambrell et al. 1976, Brannon et al. 1976, deGroot 1979, Johnston 1981, Bryan 1985), the oxidation of previously anoxic sediments acts to release those compounds which have been bound up in the interstitial water (between the sediment particles), adsorbed or attached to individual sediment grains, tied up in precipitates or coatings on particles, incorporated into or associated with the organic fraction of the sediments, or part of the crystal lattice of minerals (so-called "residual phase") (Keely and Engler 1974). Once remobilized, these compounds will not usually stay in solution for a long period of time given their affinity for particulate matter. However, during their brief sojourn into the overlying waters, they can be either absorbed or consumed by organisms in the water column, or fall back to the surface of the sediment where, in comparison to being buried deep in anoxic sediments, there is a high probability of ingestion by benthic organisms.

The cause for concern, and thereby the cause for regulation, is laid out in the following scenario, greatly simplified for purposes of illustration. Assuming that, once ingested, the toxic compound is absorbed into the tissues of the organism, either the individual dies (if the dose is of sufficient concentration), some sub-lethal effect ensues, or the compound is simply retained with no immediate physiological effect. If the process stopped here, there would be cause for little concern, but the issues of body burden, bioaccumulation and trophic transfer all become important considerations. The organism, if it eats more than one such contaminated particle, will tend to concentrate this compound in its tissues (undergoing "bioaccumulation" with the resulting concentration termed its "body burden"). If, in the course of ecological events, it is eaten by a passing predator, the predator will retain a portion of the contaminant within the tissues of the prey (transfer of the compound to a higher trophic level). Given that this predator may end up, after a time, on the dinner table, the necessity to acquire some understanding of the potential for contaminant remobilization from a given dredging project is apparent.

No simple, direct relationship exists between bulk chemical properties of sediments and ensuing changes in water quality associated with dredging (Boyd et al. 1972, Windom 1973, Keely and Engler 1974, Lee and Plumb 1974, Morton 1976, Krizik et al. 1977 Johnson 1981). Dredged material comprised of finer fractions (silt and clay) and high organic content has the greatest potential for negative adverse impact (Krenkel et al. 1976). The situation is further confounded in that these toxic compounds have widely differing chemical properties. For instance, organic compounds such as PCB and DDT are hydrophobic (very low solubility in water) whereas many trace metals, as they are found in the environment, are hydrophilic (very soluble in water). This basic chemistry can have a profound effect on the

potential for remobilization of potentially toxic compounds. Dredging is known to enhance the remobilization of PCB's (Hafferty et al. 1977) and release sulfides, a potent biotoxin and compound which exerts a high chemical oxygen demand (EPA 1977), to 1.3 to 4.0 X background levels. However, given that complex suite of reactions which results from the oxidation of sulfides, it is difficult to say whether this release has any lasting effect either directly as a toxic substance or indirectly through release of metal-sulfides (Slotta 1974).

These toxic compounds can be responsible for direct impacts to organisms. Mass mortality of fish (Ackefors and Fonsecius 1969 cf deGroot 1979, Jeane and Pine 1975) and invertebrates have been observed. Sub-lethal effects have been noted (Sherk 1971) and body burdens in deposit feeders of 3 X the concentration in the sediments are not uncommon (Rosenberg 1977). Submerged aquatic vegetation and marsh grasses are subject to contaminant uptake (Reimold and Durant 1974, Krenkel et al. 1977) although no conclusive statement of the significance of this uptake can be made without further work.

Leonard and Wang (1976) report that significant oil and grease can be released during dredging operations. With this comes a possible remobilization of those toxic compounds contained within these materials. Considering that many of the most toxic compounds are soluble in this fraction, the effects of this kind of release could be quite significant. However, the authors further state that most of this would be removed by adsorbing to the settling sediment particles. This has been suggested as a positive effect in that the suspended sediment may act to scavenge contaminants from the overlying waters (Bouma 1976), but no evidence has been provided to support this speculation.

As will be discussed in Chapter 6, testing procedures have been devised to provide some estimation of the amount of material which can remobilize in a given situation, called the elutriate test, sediment grain size analyses which indicates the size fractions within the sample from the site, bulk sediment analyses which determine how much of each compound or group of compounds is contained within the dredged material, and bioassay/bioaccumulation tests which estimate how much mortality will result from disposal of the material and how much will accumulate in various types of organisms.

## D. PHYSICAL EFFECTS:

SECTION SUMMARY

- impacts usually are gradual, insidious and may be environmentally and economically devastating (p. 4-17)

- new sediment surface exposed by dredging or created at

SECTION SUMMARY: PHYSICAL EFFECTS (CONTINUED)

disposal sites may act differently than current sediments with regard to how easily it is picked up by currents (p. 4-17)

- potential adverse impacts include (pp. 4-17, 4-18, 4-19)
  - changes in current direction and velocity
  - expand wave action and bottom scour
  - increase sediment transport rates and modify sedimentation patterns
  - change wave refraction patterns...increase in coastal erosion
  - may increase fresh water runoff...disrupt nutrient inputs and groundwater supplies...change salinity regime in estuaries impairing nursery and habitat function
  - increase possibility of saltwater intrusion into groundwater
  - loss of submerged aquatic vegetation (e.g. eelgrass)... impairing nursery and habitat function as well as bottom stability and wave buffering capacity
  - chronic and cumulative effects have been reported

Physical alterations to estuarine and coastal systems, whether natural or man-made, are some of the most important and far reaching of the effects of dredging and dredged material disposal. These modifications can alter the biological and chemical components of the system, producing effects that are insidious, gradual, and perhaps even economically devastating.

The coastline is a delicate balance of forces and accommodations. Anything that alters the current pattern, the character of the sediment surface, or the topography of the seabed, changing the magnitude and direction of the forces at work or impeding the sediment from moving in response, will move the system out of equilibrium. Dredging and dredged material disposal can produce these alterations (Rees 1980, Johnston 1981, O'Conner 1983).

When material is removed during a dredging operation, the underlying material becomes the new sediment surface; disposal has a similar effect. If the grain size, particle-to-particle adhesion, water content or other characteristic has been changed in the process, the ability of the material to move in response to currents has changed as well. Gerges and Stanley (1985) found that dredging to deepen the Suez Canal exposed sediments that were able to be moved at lesser current velocities, thereby exposing it to resuspension from the passage of large ships. If the channel cut results in a decrease in current velocities (e.g. if the

cross-sectional area of the channel is widened but not deepened), the character of the sediments will change because finer materials will be allowed to settle out (Kaplan et al. 1975).

The removal of bottom features, such as shoals, may cause changes in current direction and velocity, expand wave action and bottom scour, increase sediment transport rates, modify sedimentation patterns (Bouma 1976). O'Conner (1983) indicates that any change in bed topography will lead to a corresponding change in sediment movement (see also Palmer and Gross 1979). He further states that, in offshore situations, increasing depth from dredging will lead to a change in the wave refraction patterns and re-focus wave energy to different coastal areas, exacerbating coastal erosion problems. Dredged holes may attract flow which may alter patterns of tidal ebb and flow, perhaps causing problems for shipping interests. Disposal in land reclamation areas can also cause problems. Containment areas, whether intertidal or islands created for the purpose of dredged material disposal, change the local geometry of the seabed. If smooth embankment walls are used, flow attraction may lead to changes in channel configuration. Problems both upstream and down may result from eddy zones near the fill. If the proposed dredging is located in the intertidal zone, it may remove intertidal volume and cause changes in channel depth further down the estuary. He further observes that in instances of maintenance dredging, changes result from inefficient disposal practices. If the material is placed too close to the dredged area, it will, more often than not, return quite quickly. This will result in, among other things, the loss of depth in the channel from bulking (i.e. settling back but with a higher water content, and therefore taking up greater space) sediments and increasing resuspension and turbidity. The author cites, as an example, the problems resulting from deepening the navigation channels of Savanah Harbor from 7.9 to 11 meters. The existing siltation in the Harbor is associated with a simple gravitational circulation pattern with a single nodal point accounting for 80% of the dredging in the estuary. Because of the deepening over the past 60 years, the nodal point has moved landward and siltation has increased from 2.3 million cubic meters to 5.7 million. The reason for this landward advance is the greater hydrostatic thrust of the seawater in the deepened section of the channel, allowing the more saline, and therefore more dense, water to penetrate further into the estuary. The increase in total dredging is associated with an increase in the magnitude of the recirculating flow in the gravitational circulation, which arises from an increased near bed, longitudinal density gradient. While the physical oceanography may be interesting, the bottom line costs to Savanah for maintenance dredging may mean the difference between their success and failure as a shipping port. This would indeed (sensu Palmer and Gross 1979) make dredging a self-perpetuating process.

Deep canals and channels may accelerate run-off, lower freshwater aquifers , disrupt nutrient inputs, reduce hydraulic buffering effect of shallow flats, and create nutrient sinks and dense, hypersaline waters (EPA 1976). Changes in the salinity regime may eliminate or substantially alter the broad mixing zone important as a nursery for juvenile fishes and

invertebrates (EPA 1976). Saltwater intrusion into groundwater may also be a side effect from the increased penetration of saline waters into estuaries. Overdraining caused by channelizing coastal watershed streams can also lead to saltwater intrusion by lowering the freshwater head and reducing the hydroperiod (LaRoe 1977).

Another possible effect of dredging is the loss of submerged aquatic vegetation (SAV) and marshlands. Because dredging results in deepened areas or depressions in the bottom, the depth may be beyond the depth of light penetration sufficient to support SAV such as eelgrass (Zostra) or other types of vegetation. This would prohibit recolonization of these plants which are important in stabilizing exposed and submerged sediments.

In terms of chronic and cumulative effects, Jones (1981) found that dredging of a commercial port in Australia has resulted in the harbor becoming progressively more muddy and turbid, exacerbated by the resuspension of fines from shipping traffic. Through deposition of fine materials discharged from a number of dredge and disposal operations and changes in circulation patterns which increased the deposition of fluvial suspended sediments, the sedimentation patterns and ambient conditions of this harbor have been irreversibly altered.

It is not difficult to see, in light of the foregoing discussion, that physical alterations to a coastal or estuarine system can have significant negative adverse effects. This is also the area where, in most cases, the least amount of information is available, given that physical oceanographic data is difficult and expensive to collect and is not routinely required by regulatory agencies.

## D. MITIGATION OPTIONS:

SECTION SUMMARY

- important to look at secondary effects e.g. will project increase boat traffic or shoreside development to unacceptable levels (p. 4-20)

- also important to assess which species or resources are most important...identify which species or resources are most critical from an economic standpoint (e.g. quahogs, scallops, flounder) and on ecological grounds (e.g. eelgrass beds, seaworm flounder food, endangered species) (p. 4-20)

- pre- and post-project monitoring important especially for larger projects (bathymetry at a minimum) (p. 4-21)

- dredging windows useful only if properly applied...establish

SECTION SUMMARY: MITIGATION OPTIONS (CONT.)

restrictions based on best available life history information, type of dredge used, and sediment characteristics (p. 4-21)

- silt curtains effective only under very restrictive set of conditions (p. 4-21, 4-22)

- other mitigation possibilities include (pp. 4-22, 4-23)

  - maximize use of natural channels
  - avoid saltmarshes, shellfish and eelgrass beds
  - include setbacks of at least 25' from edge of saltmarsh
  - provide area for future disposal of material from maintenance dredging operations

Considering the many potential impacts discussed above, one wonders how the regulatory standard of "minimize adverse impact" can be achieved. Short of cancelling the project, mitigation is usually unavoidable. Given that most dredging projects are, at least to the project proponent, essential for assuring safe passage for vessels using the waterway or some other justification, the is a diverse universe of mitigation techniques and design standards available to the dredging project planner.

The cardinal rule of dredging mitigation is that the project should only be as large as is necessary to meet the most basic needs of the targeted user group. The main channel configuration for Boston Harbor will be significantly different from one in Harwich. In New York (Hamilton 1985), channels for recreational vessels less than 20' are limited to 4' depth, 1' overcut, and 50-100' width with 1:3 side slopes. Larger recreational harbors are limited to 6' depth, 1' overcut, and restricted to the same width. The only exception to this guideline of minimizing the scope of the project is, where possible, to extend the length of a dock or pier to reach deeper water, eliminating the need for dredging. It is extremely important that the user groups be identified in the planning process so that the scope of the project can be appropriately determined.

In order to provide appropriate mitigation, it is essential that all aspects of the project be considered in the impact assessment. During this assessment, species and resources of particular economic or ecological concern should be emphasized. If, for example, a dredging project is proposed for Nantucket Harbor, it would be important to consider the life history characteristics of the bay scallop, a species very important to the local economy, when determining the timing of the project. It would also be wise, from an ecological standpoint, to avoid eelgrass beds, as these are preferred habitat for the scallop, and other

species of ecological and economic importance. Continuing this example, if using the dredged material as sand for beach nourishment, certain restrictions may be established if the nourishment site is nesting habitat for the piping plover, a threatened species.

In addition to assuring the protection of ecologically/economically critical resources, it is important to assess not only the impacts from the project itself, but also its potential cumulative impacts. Most of these secondary effects are difficult to identify and adequately assess. Examples of appropriate questions include: Does the project increase boat traffic...is it designed to minimize future maintenance dredging? Benefits and detriments must be considered in this area as well. Will this dredging stimulate the development of the waterfront and if so, are controls in place to assure that the development or rehabilitation of these areas are most appropriate?

The project should be monitored before, during and after the actual dredging activity, the scope of this monitoring determined well before the date the project is scheduled to begin. All scientific information available regarding the site should be collected and assessed to determine whether sufficient information exists to address the potential impacts. At a minimum, a pre-dredge survey of the bottom topography and conditions, a basic understanding of current and sediment regimes, some indication of the benthic community structure (at least estimates of shellfish populations), and some estimate of ambient water quality are essential for a reasoned decision. Seek professional scientific assistance to assure that this scope is complete and reasonable for the given project. The importance of monitoring during the project cannot be over emphasized. Assuming that the regulatory agencies have framed the various permits with conditions that are enforceable, much environmental damage resulting from inefficient or careless dredging and dredged material disposal can be avoided by inspecting the site during the operation (Ingle 1952). A post-dredging hydrographic survey would be the minimum for monitoring once the project has been completed (pre- and post-dredging surveys are a standard practice of dredging contractors, used to show that they satisfied the terms of the contract); additional information requirements will site-specific. Although the scale of the project will ultimately determine the scope of the program, monitoring is essential for assuring that the appropriate level of environmental protection is achieved.

Given the foregoing discussion regarding the potential impacts from the resuspension of sediments during dredging operations, it would seem appropriate to attempt to isolate the resource from the cause of concern. The two most common mitigation techniques utilize this concept but approach it in vastly different ways.

Of all potential mitigation techniques, the most widely used is timing the project in such a way that ecologically critical "windows" (periods of time where the resource being protected is most sensitive to adverse impacts) are avoided. Such "dredging windows" are generally

established by regulation and are usually a very conservative estimate of critical periods in the reproductive cycles of species protected by one statute or another. The problem with these windows is that they usually do not reflect the most up-to-date scientific information regarding the life history of the particular species, and do not take into consideration the type of dredge used or the character of the material to be dredged. If, for instance, a hydraulic dredge is being used to remove coarse sand, one might be less concerned about suspended sediment impacts than if the material is silt and the dredge a clamshell-type. In addition, a number of agencies have established, independently, their own window for a particular species. No consensus has yet been reached for any species. However, there are a growing number of regulators at all levels of government who have recognized the inherent problems with windows, and are working with other agencies to establish consensus on either new, more appropriate windows, or an assessment protocol that will replace windows altogether. Until some new, mutually agreeable policy is established, agencies are being more flexible in how windows are applied. A good, in-depth discussion of this topic can be found in LaSalle (1987).

Of other widely used mitigation techniques, silt curtains are a popular choice, though routinely misapplied and misused. The requirement that silt curtains be deployed for dredging projects has become almost automatic, when, in fact, its effectiveness has been proven to be quite limited. Only if the currents are less than approximately 0.5 knots, the material is mostly fine, unconsolidated silts and clays, and the dredging is within a relatively confined area should silt curtains even be considered. If this is found to be appropriate, the curtain deployed should be designed to withstand the extremes of environmental conditions at the site, as this is the most common source of failure, and extend deep enough to confine the material to the bottom.

Another mitigation technique still in the experimental phase is the creation of saltmarshes as replacements for those unavoidably lost to construction activities or as a productive use for dredged material disposal areas. Given the regulatory constraints on any activity within saltmarshes in Massachusetts, there has been little opportunity or need to attempt such mitigation. Those few projects that have been permitted have been limited in scope and lacking in appropriate long-term monitoring to determine the success of these efforts. In general, there have been questions raised as to the relative success of the "marsh creationists", and whether man-made marshes are, or ever will be, functionally equivalent to natural marshes. Race and Christie (1982) and Race (1985) have analyzed past marsh creation efforts, nationwide, and have found very low rates of success. While the data is convincing, the definition of "success" may require further refinement. To this end, Minello et al. (1987) provides some data which suggests that man-made marshes are somewhat less productive than adjacent natural marsh areas, but these data are not conclusive and questions have been raised as to whether the comparison of a recent man-made marsh and a more established and older natural marsh is appropriate. In light of this uncertainty, many regulators have opted to take the conservative approach. For example, the

State of New Jersey requires, in instances where marshes are unavoidably lost to development, that replacement marshes be created at a ratio of 2:1.

Johnston (1981) suggests a broad spectrum of mitigation techniques appropriate for specific circumstances. The alignment of channels should make maximum use of existing, natural channels, avoiding shellfish beds, submerged aquatic vegetation and bordering vegetated wetlands (see also Hamilton 1985). Restoring or planting submerged aquatic vegetation and marsh vegetation should also be considered.

Hamilton (1985) also makes a number of suggestions. If shellfish beds cannot be avoided, transplantation should be required at a ratio of 2 replaced:1 removed. To minimize the impact of boat wake and slumping of marsh banks, dredging within 25' of any bordering vegetated wetland should be prohibited.

Florida Coastal Coordinating Council (1973) recommends that dead end canals be prohibited, and that hydraulic dredging is, for most projects, the preferred alternative.

North Carolina Department of Natural Resources and Community Development (1985) has developed a few design standards as well. Boat basins should be dug no deeper than the channel to which they connect. They should be designed with the widest possible opening and the shortest possible entrance canal to promote maximum flushing and exchange of waters. The depth of a boat basin should decrease from the seaward end to the landward end. Concerning marinas and dredging, they cannot be located in what are termed "primary nursery areas" (defined and mapped as breeding grounds for commercially important finfish and shellfish species) nor can a channel providing access to deeper water be located in these areas. In addition, marinas are required to provide not only a location for disposal of the material dredged during construction but sufficient to contain materials from all future maintenance dredging activity.

The Guide to the Massachusetts Coastal Wetlands Regulations (DEQE/MCZM 1978) also provides specific recommended mitigation techniques specifically within the framework of the Wetlands Protection Act. This section has been included in its entirety in Appendix A.

Mitigation, no matter what form it happens to take, cannot be assumed to be effective merely because it is widely used. It is offered as a possible solution to an impact which seems to be unavoidable. The questions are, 1) is this impact really unavoidable or can the project be altered or scaled down to eliminate the impact altogether, and 2) if the mitigation is necessary, will it be sufficiently effective to minimize the the effects of the activity? Ultimately it becomes a question of how much is "minimal", and, if a standard is relevant, if that standard is met by the project and proposed mitigation.

## THE REGULATORY FRAMEWORK; GETTING IT DONE

What makes dredging and dredged material disposal such an entity unto itself is not so much the activity, but the number of people who have to approve, or at least take a look at, your project before the bucket hits the water. A project proponent is subject to nearly 40 sets of applicable statutes and regulations and may be required to secure as many as 10 permits, licenses, and other authorizations for a major dredging project.

As distasteful as it may be to some, acquiring a working knowledge of the regulatory framework as regards dredging and dredged material disposal is essential. Without some knowledge of the major players, their role in the process, and generally what information they may require, much time, energy and expense will be wasted. This familiarity with the process may ultimately be the difference between the eventual success or failure of the project.

The format of this chapter is such that one may derive a quick overview of a particular program through reading the information contained in the "box" which preceeds each section or get the full story by examining the narrative description and discussions of "how to file" and "the review process". Each major program or agency has been treated separately...the more advisory or "special circumstance" programs have been combined in "Other Agency" sections. While the information contained in the descriptions is as current as printing technology will allow, it is always best to check the latest regulatory changes directly with the agency.

In the "words of advice" category, the importance of patience, persistence and good planning cannot be overemphasized. The regulatory process is complex and cumbersome, which means that everything takes time...lots of time. It is not the time to begin to fill out the permit and funding applications when the entrance channel shoals in or a few months before the boats are expected back at the slips of the marinas. "Murphy's Law" is fully engaged when it comes to regulation and permitting. The need for dredging must be anticipated far in advance of when it actually must be done. At each step in the process, you must present accurate and sufficient information - and expect to have to supply even more at some time during the process. It is easy to get discouraged before you start but, like most things, the project is worse in the anticipation than in the doing...persistence will eventually mean success (unless your project is fatally flawed...something that will be evident from the outset). Don't panic when the process bogs down and deadlines loom...it just means that you started too late...learn from your mistake and move on. If you remain flexible, provide timely information, and keep up with the process, you are bound to succeed.

## LOCAL AGENCIES: CONSERVATION COMMISSION

PERMIT: Order of Conditions (State Wetlands Protection Act) and Local Permit (local Wetlands Protection By-Law, in many instances)

AGENCY: Town or City Conservation Commission

AUTHORITY: Massachusetts General Laws, Chapter 40, Section 8C (Conservation Commission Enabling Act); Massachusetts General Laws, Chapter 131, Section 40 (Wetlands Protection Act); 310 CMR 10.00 (WPA Regulations) Local Wetlands By-Law

JURISDICTION: Construction activities that are in the 100-year flood plain (by-laws may extend to 100 feet landward of the 100-year flood level), and within 100 feet of any vegetated wetland or other resource area protected under the act, or any activity which involves dredging, filling or otherwise altering waterways within the town.

FEE: Generally $25.00 but may vary depending on the filing requirements of the individual town.

REVIEW PERIOD: At least 42 days from the date the Notice of Intent (NI) is received by the Commission

PREREQUISITES: None

TIMING: Prior to construction; should be one of first applications filed; applications must have been made for all other local permits

PERMIT LIFE: At least 3 years but may be extended to 5 years under specific circumstances spelled out in the NI...maintenance dredging good for 10 years unless stated otherwise in the NI.

RENEWAL: Extensions of up to 3 years may be granted at the discretion of the Commission

DOCUMENTATION:
- Completed NI and local application if necessary
- locus map and location map
- plan of the project, under stamp and signature of a registered professional engineer, showing location of proposed dredging and dredged material disposal
- sediment characterization (as necessary)
- other submission requirements as established under the provisions of the local by-law

CONTACT: Local Conservation Commission Office, usually located at the town or city hall.

## DETAILED DESCRIPTION: CONSERVATION COMMISSION

The Wetlands Protection Act (WPA), and regulations promulgated thereunder, provide that local conservation commissions act as the regulatory agency which reviews applications for work falling under the jurisdiction established in the Act. This jurisdiction is rather broad and encompasses any activity which involves filling, dredging, removing, or altering:

1) any coastal wetland, coastal beach, dune, tidal flat, salt marsh, estuary, creek, river, stream, pond, or lake, or waters that are anadromous/catadromous fish runs, or...

2) land under said waters, or...

3) land subject to tidal action, coastal storm flowage, or flooding.

The purpose of the Act and supporting regulations is to protect eight public interests provided by various wetland resource areas. These interests, as defined in the WPA and related legislation, are:

fisheries
land containing shellfish
storm damage prevention
flood control
groundwater
prevention of pollution
public or private water supply
wildlife habitat

The Coastal Wetland Regulations, cited above, include performance standards for projects proposed on, in, or adjacent to:

land under the ocean
designated port areas
coastal beaches
coastal dunes
barrier beaches
coastal banks
rocky intertidal shores
land under salt ponds
land containing shellfish
salt marshes
anadromous/catadromous fish runs

In addition to the WPA, many towns have also adopted, under their so-called "home rule" authority, wetlands protection by-laws which enhance the minimum protection to resource areas afforded by the WPA. These by-laws can be a part of the town's zoning regulations (in which case the

Zoning Board of Appeals may have the regulatory authority...see "Local Agencies: Other Relevant Programs and Policies", directly following this section), but more often it is a general by-law, independent of other local regulation.

Because local by-laws may vary significantly in scope and detail from one town to another, suffice it to say that the proponent must, very early in the planning stages of a project, contact the local conservation commission. This initial inquiry will provide information regarding what public interests, in addition to the eight of the WPA, are to be considered, what resource areas are protected, what performance standards must be met, and what information must be submitted to the commission as per their submission guidelines or regulations. Conservation commissions generally encourage project proponents to contact them as soon as possible so that the "ground rules" are understood by all from the outset, and that problems and be identified and resolved at an early stage of the process.

Procedural regulations regarding applications, timetables, and hearings usually, but not always, parallel those in the WPA and Regulations. Applications can be either joint WPA/By-Law forms, a modified version of the State's <u>Notice of Intent</u> (NI) or separate forms for each. Hearings are usually held concurrently and the WPA regulatory timetable is the accepted norm. Appeals of decisions made by conservation commissions <u>under their local by-law</u> are made to the Superior Court of the Commonwealth of Massachusetts [a point worth emphasizing given that it produces a great deal of confusion...when the DEQE issues a Superseding Order of Conditions- see "State Agencies: DEQE-DWWR (WPA Appeal)"- it does not, <u>in any way</u>, affect the decision under the town by-law...this decision is still in force until a Superior Court judge renders his or her decision in an appeal].

Given that these by-laws have been, in decisions arising from various test cases, judged by the courts to be proper in enhancing the protection afforded by the WPA and Regulations, and that most towns take this notion of enhanced protection seriously, satisfying the requirements under the local by-law may be (and usually is) a more difficult task than meeting the provisions and performance standards set forth in the WPA and Regulations.

In general, once the NI is received by the local conservation commission, a hearing is held to allow the proponent an opportunity to describe the project to the commission and allow the commission the opportunity to ask any questions it may have regarding the project. Once the commission is satisfied that they have sufficient information to render a decision, they will close the public hearing and, within 21 days issue an <u>Order of Conditions</u> (OC or Order). This OC may just apply to the decision under the WPA, in which case a separate local permit will be issued, or may also serve as a permit under the local wetlands protection by-law. The Order is essentially a listing of conditions and provisions which, if rigorously followed by the proponent, will allow the project to meet the letter and spirit of the WPA (and local by-law). Should an

applicant ignore any provision of the OC, the proponent would be subject to rather stringent criminal and/or civil penalties.

The OC is generally effective for three (3) years, but may, under very restrictive circumstances, be made valid for up to five (5) years. Under the WPA, maintenance dredging activities are permitted for up to ten (10) years from the issuance of an Order, but requires prior notification of the conservation commission and restricts activity to maintenance dredging and dredged material disposal only in those areas referenced in the original OC.. Local by-laws , on the other hand, may require that the proponent secure a new Order for each proposed maintenance dredging project.

Appeals of decisions under the WPA and Regulations, unlike those of by-laws which go directly to the courts, are made to the Department of Environmental Quality Engineering, Division of Wetlands and Waterways Regulation [see "State Agencies: DEQE-DWWR (WPA Appeal)].

<u>HOW TO FILE</u>

- Contact your local conservation commission to inquire as to local by-law provisions and requirements...obtain appropriate application forms. The local Commission is the initial contact point for many of the subsequent regulatory actions... notifications of additional actions on the part of the project proponent will occur as a part of this process.

- Submit to conservation commission:

  - Completed Notice of Intent and local by-law permit application (if required)

  - any additional information as requested by the commission either verbally or through submission regulations or guidelines

  - Filing Fee (as per local fee schedule)

  - Area map (based on USGS Quad. Sheet) and locus map (showing nearest roads and landmarks)

  - Plans and specifications for the project under stamp and signature of a registered professional engineer

  - Any environmental testing results that may be appropriate for the project (see Chapter 6, "Environmental Testing Requirements")

- Send a copy of the NI to the regional DEQE office

## REVIEW PROCESS

It is generally a good idea to meet with the commission or its administrator or agent to review the project. Especially when dealing with large and complicated projects like dredging, this kind of consultation goes a long way to avoid problems once the commission actually "receives" the NI and the 21-day time clock begins to run. Commissions, like most other groups of human beings, tend to get nervous when under a time limit. This is not an atmosphere conducive to sorting out problems and undertaking friendly negotiations. If you give the commission (or its representatives) a chance to review a project before the fact, the process seems to go a little more smoothly. If the commission feels that additional information is necessary, this early review will allow the proponent the opportunity to supply it without being boxed into a position of either having to request a continuance of the public hearing or having the commission deny the project because of a lack of information.

- Once the commission officially "receives" the NI, it must hold a hearing on the application within 21 days.

- At the public hearing, the proponent will usually be asked to give a brief explanation of the project, the commission will ask the applicant questions regarding the project, and the public will be given the opportunity to comment and ask questions. If the commission is satisfied that they have sufficient information to render a decision and that all who wish to comment have done so, the hearing will be closed.

- Within 21 days of the close of the public hearing, the commission must issue an Order of Conditions.

- If: the applicant,
  any abutter to the project,
  any ten residents of the city or town in which the work is proposed,
  any person aggrieved by the Order, or
  the DEQE

  does not agree with the OC issued by the commission or believes that the commission has been capricious and arbitrary in their decision, that person or persons has 10 business days from the date of issuance of the OC to make their objections known to the DEQE regional office.

- Once this appeal period has passed, the proponent must file a copy of the Order at the local Registry of Deeds...it is not in force without this action and activities begun prior to the registration of the Order are in violation of the WPA, and therefore subject to civil and criminal fines and penalties.

- Once the project has been completed, the proponent must request a "Certificate of Compliance" from the conservation commission. The Certificate of Compliance is a verification by the Commission that a project has been completed as conditioned in the OC. A parcel under an outstanding Order of Conditions often cannot be bought or sold because any existing violations are conveyed with the property.

## CONTACT

Local conservation commission in the town in which the project is proposed...usually located in town hall. If the project crosses town lines, applications must be filed in both towns separately.

## LOCAL AGENCIES: OTHER RELEVANT PROGRAMS AND POLICIES

At least four other local agencies may be encountered in the permitting process for dredging projects. Their role may be advisory to the conservation commission or regulatory in their own right depending on the town and any by-laws town meeting may have passed. Usually, the initial meeting with the conservation commission will help to identify the appropriate contacts within the town, but there is some benefit in asking specific questions.

Boards of Selectmen: As the elected representatives of the town, boards of selectmen have broad powers, both those they have acquired through the evolution of town government and those thrust upon them by State and local regulation. In small coastal towns, selectmen seem to have a propensity for involvement in matters pertaining to the harbors and waterfront...not too suprising given the historic importance of the harbor area to most of these towns. As such, boards may have a specific interest, regulatory and otherwise, in proposed dredging projects, and should be contacted if there is some indication that they have a role in the process. This is, of course, especially true with regard to projects involving public access.

Zoning Boards of Appeal: If the local wetlands by-law is based in the zoning by-laws of the town, there is an outside chance that a dredging project may be required to go before the zoning board of appeals. This is a greater possibility when the project involves the construction of structures. However, given recent judicial activity regarding local zoning of the "watersheet" (planner's jargon for any area seaward of the high water mark), the possibility of having to appear before this board may be increasing somewhat. Given that "watersheet" projects are a new area for zoning boards of appeal, the information may have to be presented in a somewhat different manner than the approach one would use for a conservation commission.

Shellfish Wardens/Biologists-Natural Resource Departments: Given that dredging usually involves shellfish, in one way or another, the local agency responsible for this area will almost assuredly be involved, whether in an advisory capacity to the conservation commission or directly as a regualtory agency. Recommendations from this person or agency to the conservation commission can have a profound effect on the outcome of their decision. There is a significant benefit in contacting these folks very early in the planning process so that later problems can be avoided. Given that "land containing shellfish" is a protected interest in the WPA and most local by-laws, the reason for this contact is obvious.

Harbormaster-Harbor/Waterways Commissions: While the interests of these folks are a bit different from the shellfish biologist, it is certainly as important. Dredging is, after all, a primary responsibility of the harbormaster and of paramount importance to harbor commissions whose responsibilities include planning for anchorage areas and marinas, both public and private. Again, early contact is strongly advised.

STATE AGENCIES: DEQE/DWWR (WPA APPEAL)

PERMIT: Superseding Order of Conditions
Final Order of Conditions

AGENCY: Department of Environmental Quality Engineering, Division of Wetlands and Waterways Regulation

AUTHORITY: Massachusetts General Laws, Chapter 131, Section 40 (Wetlands Protection Act), and 310 CMR 10.00 (WPA Regulations)

JURISDICTION: Appeals of Orders of Condition written by local Conservation Commissions under provisions of the Wetlands Protection Act

FEE: None    TIMING: Following the issuance of an Order of Conditions

REVIEW PERIOD: 70 Days to issuance of a Superseding Order of Conditions ...Adjudicatory Hearings leading to a Final Order of Conditions may take 6 months to a year...appeals to the courts may take several years to complete

PREREQUISITES: Typically, local Order of Conditions being appealed, but not necessary for the issuance of a Superseding Order of Conditions

PERMIT LIFE: Same as Order of Conditions, 3-5 years and 10 years for maintenance dredging

DOCUMENTATION: Appeals of the local Order requires submission of all information supplied to the Conservation Commission during its review...an Adjudicatory Hearing may involve formal depositions and expert witness testimony

CONTACT: DEQE- Wetlands and Waterways Regulation (Main Office)
One Winter Street
Boston, Massachusetts 02108
(617) 292-5695

DEQE- Northeast Region (Salisbury to Cohasset)
209 New Boston Road
Woburn, Massachusetts 01801
(617) 938-0320

DEQE- Southeast Region (Scituate to RI Border inc. Cape Cod and the Islands)
Lakeville Hospital
Lakeville, Massachusetts 02346
(617) 947-1231 x 680

## DETAILED DESCRIPTION: DEQE/DWWR (WPA APPEAL)

If the local conservation commission fails to act in a timely manner, the applicant may appeal to the DEQE. Once a local conservation commission comes to a decision and issues an Order of Conditions (OC or Order), there is recourse for the person, whether applicant, abutter, a "person aggrieved", a group of ten residents, or the DEQE itself, who feels that the decision the conservation commission has made under the Wetlands Protection Act (MGL c. 131, s. 40) is inconsistent with the Act or its regulations and does not contribute to the interests of the Act. This appeal is made to the DEQE, Division of Wetlands and Waterways Regulation and must be received within ten (10) business days from the date of issuance of the Order. It should be understood, from the outset that this is a process that may involve much time and expense, taking, depending on how far the appeal is pursued, anywhere from three months to several years. It is, therefore advisable if at all possible, to come to terms with your local conservation commission and avoid the appeals process (plus, if the town has a local by-law, this appeal will involve the courts directly, meaning another significant drain of time and money). However, if your heart is pure and your cause just, read on.

The first line of appeal is the request for a Superseding Order of Conditions (SOC), and is made to the appropriate DEQE regional office. Once the request is made, the regional staff will review the information submitted to the conservation commission by the applicant, the minutes of the public hearing (if made available to them), and the Order issued. If the conservation commission issues a denial of a project on the basis that inadequate information was made available to them by the applicant, the DEQE review is restricted, by regulation, to only that information available to the conservation commission and which formed the basis of their decision. If, however, the commission issues an order either approving or disapproving the proposed work after determining that adequate information was available, the DEQE may request additional information, plans, or documentation within 30 days of the receipt of the appeal. Before issuing a SOC, the DEQE will hold a "site visit" to view the area and discuss the case with the commission, proponent, and any interested parties. Within 70 days from the date the appeal was received by the DEQE, or within 40 days of the receipt of requested additional information, the DEQE regional office will issue a Superseding Order, detailing the conditions the Department considers appropriate in light of the review. The SOC and any subsequent decisions of the DEQE in the appeal are part of a totally separate process from the commission's action under their local town by-law.

Once the SOC is issued, this too can be appealed with a "claim for an adjudicatory hearing" by anyone eligible to request an SOC, except additionally that any ten citizens of the Commonwealth may appeal a SOC, again within ten business days of issuance of the Superseding Order. A meeting will be scheduled which includes the Department (represented by the regional reviewer and a DEQE attorney), the party seeking the appeal,

and other interested parties. This meeting, called the "pre-hearing conference", will usually be conducted by the DEQE attorney assigned to the case and is held as a kind of combined fact-finding/mediation session. If the conflict cannot be resolved at this point, or the parties involved cannot reach consensus after further discussion, an Adjudicatory Hearing date is set, and all parties involved are so informed. At the hearing, the hearings officer receives testimony from the parties involved, including any expert witnesses who have been asked to provide opinions regarding the facts of the case. Hearings are conducted in a manner similar to, but less formal than, standard courtroom procedure. Once all the testimony has been heard, the hearings officer makes findings of fact, essentially a recommendation, to the Commissioner of the DEQE, who issues the Final Order of Conditions. This decision may be appealed to the Superior Court of the Commonwealth of Massachusetts.

HOW TO FILE

- A request for a Superseding Order of Conditions must be made in writing and sent by certified mail or hand delivered to the appropriate DEQE regional office within 10 business days of the issuance of the Order of Conditions. The request should state clearly and concisely the objections to the Order, how it is inconsistent with the WPA and Regulations promulgated thereunder, and how it does not contribute to the protection of the interests identified in the WPA. The request should include all information originally submitted to the conservation commission, and a copy of the Order of Conditions.

- A request for an adjudicatory hearing is made in a similiar way but includes the information generated in the Superseding Order process.

REVIEW PROCESS

- Request for Superseding Order of Conditions made to appropriate DEQE regional office within ten (10) business days of issuance of the Order of Conditions from the local conservation commission.

- The DEQE must notify the applicant within 30 days from the the receipt of the request if additional information is deemed necessary and appropriate.

- Before the SOC is issued, a site visit must be held involving all parties of record...the case is discussed and the site examined.

- Within 70 days of the receipt of the request, not including the time taken by an applicant to respond for a request for additional information, the SOC must be issued.

- Once the Superseding Order is issued, an appeal can be made within 10 business days of issuance, claiming an adjudicatory hearing.

- A pre-hearing conference will be held to try narrow the issues relevant to the case or to reach a settlement.

- If no resolution possible, adjudicatory hearing held and Final Order issued.

- This Final Order can be appealed in Superior Court

STATE AGENCIES: MEPA

PERMIT: Certificate of the Secretary of Environmental Affairs

AGENCY: Massachusetts Environmental Policy Act (MEPA) Unit

AUTHORITY: Massachusetts General Laws, Chapter 30, Sections 62-62H; MEPA Regulations, 301 CMR 10.00

JURISDICTION: Generally required for major projects defined by thresholds in the Regulations (see details below)

FEE: None

TIMING: Concurrent submission with other state permit applications

REVIEW PERIOD: 37 days if EIR is not required and 3-12 months if EIR is required

PREREQUISITES: None

PERMIT LIFE: 5 years

RENEWAL: Request by letter

DOCUMENTATION - Copy of the public notice published in local newspaper by applicant regarding filing of ENF
- Completed Environmental Notification Form (ENF) using form available from MEPA
- Site plan and locus map of proposed project

CONTACT: Massachusetts Environmental Policy Act Unit
Executive Office of Environmental Affairs
100 Cambridge Street, 20th Floor
Boston, Massachusetts 02202
(617) 727-5830

## DETAILED DESCRIPTION: MEPA

MEPA regulations require project proponents disclose the potential environmental impacts that will result from a project action and to use all feasible measures to avoid or minimize adverse environmental impacts. It acts as the informational clearinghouse for the regulatory agencies within the Executive Office of Environmental Affairs, allowing more efficient collection of relevant information regarding a wide range of potential environmental impacts while avoiding duplication of effort resulting from overlapping jurisdictions.

MEPA reviews information submitted by the applicant in the Environmental Notification Form (ENF) and comments from relevant local, State, and federal regulatory agencies and the public to determine whether an Environmental Impact Report (EIR) will be required.

No state permits may be issued until the Secretary of Environmental Affairs certifies either that:
1) No EIR is required...in cases where the information submitted is judged by the Secretary to sufficiently describe the potential environmental impacts and appropriate mitigation, or...
2) An EIR is required, its scope of work is established, and the study is completed to the satisfaction of MEPA and the Secretary.

Thresholds which include a project in the MEPA review process are defined in the MEPA regulations. For a complete listing of these thresholds, see the regulations cited above or contact the MEPA office. The following are examples of categories and thresholds for inclusion which require an ENF pertain to dredging and related projects:

1. Projects requiring the issuance of a Superseding Order of Conditions [See "State Agencies: DEQE-DWWR (WPA Appeals)", this Chapter] where more than one acre of resource area subject to the Coastal Wetlands Regulations (e.g. saltmarsh, tidal flat, etc.) is involved.

2. Projects proposed under a Chapter 91 license that involve the filling, dredging, constructing, riprapping or other direct alteration of more than 500 feet of waterway bank.

3. Projects involving the licensing of construction for new marinas having more than 50 slips.

4. Projects involving the dredging of 10,000 or more cubic yards of sediment.

## HOW TO FILE

- Examine Section 11.28 of the regulations cited above and consult with the MEPA Office to determine if an ENF must be submitted for the project.

- If the project meets any of the review thresholds in Sections 11.25 through 11.27 of the MEPA Regulations, the applicant must submit an Environmental Notification Form (ENF) to the MEPA Unit and to all participating agencies and entities as designated in Appendix B (Section 10.31) of the MEPA Regulations.

- As described above, the ENF, when completed, provides preliminary information on the project, including conceptual plans, anticipated environmental impacts, and proposed mitigation. MEPA must receive the ENF no later than 10 days after the filing any application for state permits or for state financial assistance.

- When the project proponent is a state agency, the ENF will usually be filed: 1) one year prior to the projected project commencement date; 2) prior to entering into a contract for the final design; or, 3) within 10 days of the submission of any permit application to another agency, whichever is earliest.

- If, at any time after the ENF is filed, there are changes to a proposed project, the applicant must notify the MEPA Unit. At that time, a decision will be made as to whether the change significantly affects the environmental consequences of the project and warrants additional review or submission of a new ENF. Examples of such project changes include modifications in project size, or alterations in the volume or toxicity of pollutant discharge.

## THE REVIEW PROCESS

### ENF and Comment Period

- The first page of each ENF will be published by the MEPA Unit in the Massachusetts Environmental Monitor, initiating a 20-day public comment period.

- During this comment period, the proponent and members of the public consult with and submit recommendations to the MEPA Unit regarding the necessity for the preparation of an EIR, and, if required, questions the EIR should address.

### Decision on the ENF

- Within 10 days of the end of the public comment period, the Secretary of Environmental Affairs will issue a certificate stating whether or not an EIR is required.

- If the project requires an EIR, the MEPA Unit will define the

scope of the EIR during the initial 20 day review period, in consultation with the applicant and participating agencies. The scope will describe the form, content, level of detail and alternatives required for the EIR and may establish other guidelines as to its preparation and issued as part of the Certificate of the Secretary of Environmental Affairs.

<u>Draft EIR</u>

- The draft EIR must be submitted by the applicant to the MEPA Unit and to other agencies listed in the MEPA regulations. Notice of the availability of the Draft EIR will be published in the <u>Environmental Monitor</u>. Comments by agencies and the public on the Draft EIR must be received by MEPA within 30 days of publication.

- Within 7 days of the end of the Draft EIR public comment period, the Secretary of Environmental Affairs will issue a written statement indicating whether or not the Draft EIR adequately complies with the MEPA regulations and the scope.

<u>Final EIR</u>

- After receipt of the Secretary's Certification regarding the Draft EIR, the proponent must answer all questions raised by reviewers of the Draft EIR in a Final EIR. Once completed, the availability of the Final EIR must also be published in the <u>Environmental Monitor</u>.

- Public comments on the Final EIR must be received by MEPA within 30 days of publication of its availability.

- Within 7 days after the end of the public comment period, the Secretary will issue a written statement indicating whether the Final EIR adequately complies with its regulations.

- If an EIR is required for a project, state agencies may not act on permit applications, funding requests, and the like, until 60 days after the availability of the Final EIR but should act within 90 days of publication of the notice of availability of the Final EIR, unless the filing to these agencies are incomplete.

STATE AGENCIES: DEQE-DWWR (CHAPTER 91)

PERMIT: Waterways License/Dredging Permit

AGENCY: Department of Environmental Quality Engineering, Division of Wetlands and Waterways Regulation

AUTHORITY: Massachusetts General Laws, Chapter 91: Waterways Regulations 310 CMR 9.00

JURISDICTION: Waterways License: generally includes any construction activity seaward of the high tide line (dredging may be included as part of the project) Dredging Permit: project involving only dredging and subtidal dredged material disposal (beach nourishment requires Waterways License)

FEE: None

REVIEW PERIOD: Within 90 days of the completion of an application or publication in the Environmental Monitor that an EIR is not required, whichever is later

PREREQUISITES: "Notice of Intent" under the Wetlands Protection Act (MGL c. 131 s. 40) must be filed with the local Conservation Commission; " Order of Conditions received before permit issued

TIMING: Prior to construction, dredging, or filling

PERMIT LIFE: License: unlimited if project completed within 5 years of date of issuance; Permit: usually 5 years, but may, for maintenance dredging, be valid for 10 years if so requested.

RENEWAL: License: Not applicable; Permit: Reapplication as if new work

DOCUMENTATION - Completed application forms supplied by DEQE
- Plans and specifications under stamp and signature of a registered professional engineer or registered land surveyor
- ENF for projects which exceed MEPA thresholds

CONTACT: Division of Wetlands and Waterways Regulation
Waterways Regulation Program
Department of Environmental Quality Engineering
One Winter Street
Boston, Massachusetts 02108
(617) 292-5695

## DETAILED DESCRIPTION: CHAPTER 91

[At this writing, the revised Chapter 91 Regulations have not been promulgated. However, this description includes much of the substance of the draft Regulations currently under review. Should the final version of the new Regulations differ substantially from the draft version with regard to the dredging provisions, this section will be updated and made available to those who wish to keep their Dredging Handbook up-to-date.]

Commonly known as the state tidelands law, Chapter 91 regulates activities involving construction, dredging and filling carried out in tidelands, in Great Ponds (those over ten acres) and certain rivers and streams.

Traditionally, the purpose of these regulations has been to protect the public rights of navigation, fishing and fowling in the foreshore (the areas between the high and low tide marks), which is privately owned, and all rights in Commonwealth tidelands (all lands and waters seaward of the Commonwealth's jurisdiction (see fig. 5.1).

Pursuant to the 1983 amendments to the law, the term tidelands was expanded to encompass both flowed tidelands (those that presently lie between the mean high water mark and the seaward limit of state jurisdiction) and filled tidelands (those which at one time were flowed but presently lie above the mean high water mark due to the presence of artificial fill).

Chapter 91 licenses are issued by the Department of Environmental Quality Engineering (DEQE) Division of Wetlands and Waterways. No license is issued unless three basic conditions are met:

- all proposed structures and fill must comply with a set of generic requirements concerning environmental and structural criteria, as well as observe the public's right of fishing, fowling, and navigation in the tidelands of the Commonwealth.

- the project as a whole, exclusive of fill or structures for water-dependent use of private tidelands, must be determined to serve a "proper public purpose" and to provide greater benefit than detriment to public rights in the tidelands.

- all proposed structures and fill for non-water dependent use of tidelands must be consistent with the polices of the Massachusetts Coastal Zone Management Program.

In addition, Chapter 91 establishes criteria for licensing and permitting such as:

- Structural Requirements - For example, no structure may

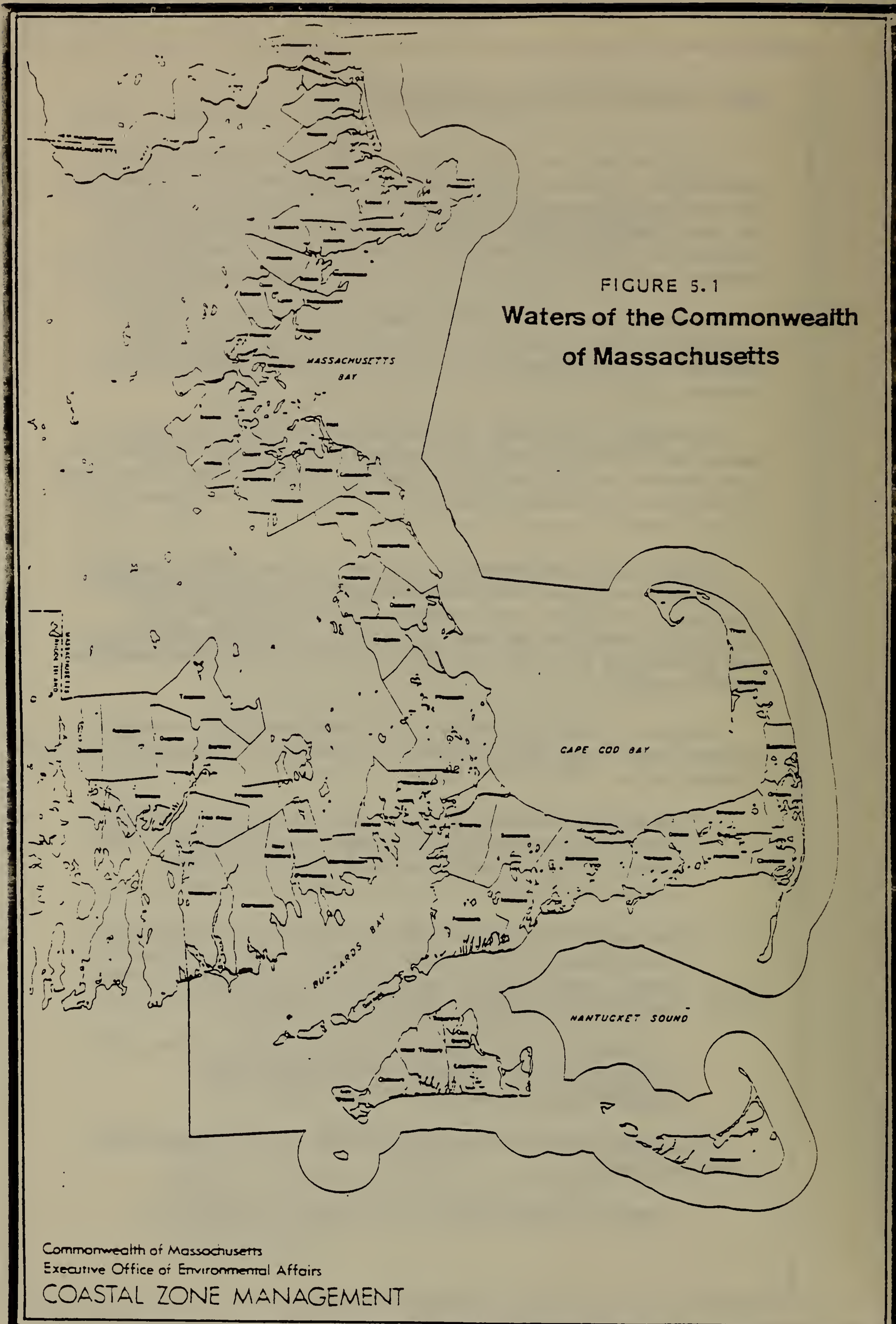


FIGURE 5.1
**Waters of the Commonwealth of Massachusetts**

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
COASTAL ZONE MANAGEMENT

unreasonably restrict the ability to dredge any channel...all coastal engineering structures are evaluated on the basis of their compatibility with abutting structures in terms of design, size, function, and material...in evaluating coastal or shoreline engineering structures, non-structural alternatives (such as beach nourishment) are required where feasible.

- Criteria Regarding Hazards to Navigation - For example, piers or other structures which extend into an existing channel and impede free passage, impair any line of sight required for navigation, or require the alteration of the established course of vessels will not be licensed.

- Criteria Regarding the Protection of Public Trust Rights in Commonwealth and Private Tidelands - For example, any dredging which significantly interferes with any person's right to approach their property from the sea will not be licensed. Similarly, all projects which will obstruct lateral access below the present high water mark must be constructed to allow for passage in the exercise of the reserved public rights of fishing, fowling and navigation.

- Criteria Regarding Dredging and Dredged Material Disposal - For example...no license or permit will be granted for projects which unreasonably interfere with navigation or significantly interferes with commercial activities...no approval for projects which pose a significant threat to shellfish beds.

- Criteria Regarding Special Management Areas - For example, no permit or license will be granted for improvement dredging in an Area of Critical Environmental Concern (ACEC) except for the purposes of enhancing fisheries and wildlife resources...no approval for the disposal of dredged material in a Designated Port Area (DPA) except for specific permitted uses as detailed in the Regulations.

HOW TO FILE

Submit to the DEQE - Division of Wetlands and Waterways Regulation the following materials:

- A completed Chapter 91 license or permit application:

- Project plans drawn according to size, scale, and color detailed in the Chapter 91 Regulations. These drawings and plans should include factors such as:

  - the state-designated harbor line and United States Pierhead and Bulkhead Lines (if any) opposite the proposed structures (may be obtained from the DEQE - Division of Wetlands and Waterways Regulation and from New England Division, U.S Army Corps of Engineers)

- shore and boundary lines

- present and natural mean high, present and natural mean low and present extreme low water lines

- all existing structures (and corresponding license numbers or other authorizations) including those standing in the water at mean high tide; delineation of any historic dredging, filling or impoundments at the site

- dimensions, outlines, and main features of all project proposals to be licensed

- the amount of fill to be placed in tidelands

- cross sections to show the number of piles (if any) to be driven and the side slopes of area to be dredged

- for dredging projects, plans shall include the principal dimensions of the dredge area footprint (i.e. outline of area to be dredged), dredge-cut side slopes, existing and proposed depth contours, and a description, plan, and location map of the dredged material disposal area

- copies of (if applicable):

    - certification from the local planning board that copies of the application and plan have been submitted to them for their review

    - certification from the local municipal clerk, zoning administrator, or building inspector that the activity to be licensed on private tidelands is not in violation of local zoning ordinances or by-laws

    - Final Order of Conditions, or copy of Notice of Intent if final order has not been received

    - copy of MEPA Environmental Notification Form, and any Certificates issued by the Secretary of Environmental Affairs regarding the project

REVIEW PROCESS

- Upon receipt of an application, the Division of Wetlands and Waterways Regulation will evaluate the need for supplemental information in making proper findings under the Chapter 91 Regulations

- A determination is then made by the Department as to whether the project represents a water-dependent use of the tidelands (all projects involving dredging and dredged material disposal are, as you might have guessed, considered water-dependent)

- Notice will be given by the Division to the aldermen, selectmen, or city-council and the conservation commission of the municipality in which the work is to be performed, and to the federal and state regulatory agencies. This notice will state that any aggrieved person or ten citizen group that submits written comments may also petition to intervene to become a party within 45 days.

- The proponent must advertise the project and mandatory public hearing in the affected city or town for one day in an newspaper having a general circulation in the area.

- Any person or organization may submit written comments to the Division and to MEPA on any license or permit application within 45 days after notice of the application is published in the newspaper.

- No permit or license will be issued sooner than 45 days after publication of the project notice in the newspaper. If the project is categorically included for MEPA review, the Chapter 91 license of permit will only be issued after the MEPA review is completed.

- The Division will act on a license or permit within 90 days after the publication in the Environmental Monitor of the availability of the Final Environmental Impact Report, within 90 days of the Secretarial determination (MEPA decision) that an EIR is not required, or within 90 days after the completion of the license application, whichever is the latest.

STATE AGENCIES: DEQE-DWPC

PERMIT: Water Quality Certificate

AGENCY: Department of Environmental Quality Engineering, Division of Water Pollution Control

AUTHORITY: Massachusetts General Laws, Chapter 21, Section 27 (12), Regulations 314 CMR 9.00; Section 401, Federal Water Pollution Control Act (33 USC 1341)

JURISDICTION: Any activity which could result in a discharge of pollutants into the waters and wetlands subject to Federal and State jurisdiction

FEE: None    REVIEW PERIOD: 30-45 days

PREREQUISITES: None    TIMING: Concurrent with other DEQE permit and license applications

PERMIT LIFE: 5 yrs. unless otherwise noted    RENEWAL: Not applicable

DOCUMENTATION:
- Completed application form supplied by DEQE
- Plans and specifications submitted for other permits
- results of physical, chemical, and biological testing on the sediments to be dredged

CONTACT: Division of Water Pollution Control
Department of Environmental Quality Engineering
One Winter Street
Boston, Massachusetts 02108
(617) 292-5673

DETAILED DESCRIPTION: DEQE-DWPC

The purpose of the Water Pollution Control Regulations is to ensure that dredging, dredged material disposal, filling, coastal construction, and discharge activities in subject waterways and wetlands of the Commonwealth are in compliance with state water quality standards and with DEQE, Division of Water Pollution Control Regulations and policies. These policies, regulations, and standards have been designed to insure that waters of the Commonwealth meet or exceed their designated use classifications.

Under the Water Pollution Control Regulations, subject waters an wetlands are those between mean high water and three miles seaward of the baseline which is the seaward limit of state jurisdiction (See Figure 5.1).

According to Section 401 of the Federal Water Pollution Control Act (33 U.S.C 1341), any applicant for a federal license or permit to conduct any activity which may result in a discharge into the subject waters of a state must provide the federal licensing agency with certification from that state's water pollution control agency. This certification must state that the proposed discharge will not violate applicable federal or state discharge limitations or water quality standards.

Thus, dredging, dredge disposal, filling in subject wetlands waterways, and upland disposal which involves dewatering runoff into those resource areas each requires a state Water Quality Certificate. The disposal of sediments in ocean waters beyond the State "three mile limit" is not regulated by the Division of Water Pollution Control.

The Division requires a completed Standard Application Form in order to determine whether a project complies with state and federal water quality regulations. This form requests detailed project information on factors such as project location, channel width and depth, volume of material to be dredged, etc. In addition, the applicant must submit the results of an environmental assessment of this material. This assessment is comprised of testing that may include grain size analysis (to determine the physical attributes of the sediment), bulk chemical analyses (to determine the concentrations of heavy metals and other contaminants in dredged material), elutriate testing (to determine to what level the contaminants in the sediment will be released, and bioassay/ bioaccumulation testing (to determine whether the material is harmful or fatal to organisms exposed to it and to determine if the contaminant will accumulate in the tissues of organisms that live on and in the sediment) [see "Environmental Testing Requirements" for a more complete discussion of this topic.

The Division will determine which tests are required, the number and location of sediment samples to be collected, and the sampling methodology. The results of each of these tests (physical and chemical characteristics) are then classified according to standards provided in the Water Pollution Control Regulations.

As part of this classification, the sediments are assigned a type according to a range from coarse grained material, such as sand, to finer sediments such as clay, and placed in categories according to their concentration of chemical contaminants. A listing of sediment types and categories, as defined in the Water Pollution Control Regulations, is provided in Figure 6.2.

On the basis of this classification and the completed application form, conditions for dredging are imposed, permitted disposal methods and site locations are stipulated, the timing of the project may be restricted during sensitive fish spawning and migration periods, and a Water Quality Certificate is issued for the project.

## HOW TO FILE

Submit to the Division of Water Pollution Control:

- a completed Standard Application Form and/or Supplemental Information Form
- results of physical, chemical and biological tests of the dredged sediments
- plans, maps, required drawings, etc.

## REVIEW PROCESS

- A Water Quality Certificate cannot be issued until the MEPA review, if applicable, has been completed. The Division will act on a Water Quality Certificate application within 90 days of the publication of the notice of the availability of the Final EIR, within 90 days of publication of the notice that an EIR is not required by MEPA, or within 90 days of the completion of the full application, whichever is the latest.

## STATE AGENCIES: MASSACHUSETTS COASTAL ZONE MANAGEMENT

PERMIT: Federal Consistency Review

AGENCY: Massachusetts Coastal Zone Management (MCZM)

AUTHORITY: [Federal act] (16 U.S.C. 1451 et seq.); [Federal Regulations] 15 CFR 930 et seq.; [State act] Massachusetts General Laws, Chapter 21A, and Chapter 6A, Sections 2-7; [State Regs.] 301 CMR 21.00

JURISDICTION: Any activity within or directly affecting land or water in the coastal zone for which federal licenses and permits are required

FEE: None REVIEW PERIOD: Usually no more than 90 days from submission of required materials to MCZM, but may be extended an additional 90 days if all necessary information has not been received

TIMING: After the issuance of all necessary EOEA permits but before the issuance of any federal permits and approvals

PREREQUISITES: Applicant must receive and provide to MCZM copies of the Final Order of Conditions under the Wetlands Protection Act, Water Quality Certificate, Waterways License or Dredging Permit, and all other appropriate EOEA licenses, permits and approvals before Federal Consistency Review can be completed

PERMIT LIFE: Not Applicable RENEWAL: Not Applicable

DOCUMENTATION:
- A copy of each federal permit application
- A written certification from the applicant stating the reasons that the project is consistent with applicable MCZM program policies
- Certification from the Secretary of Environmental Affairs regarding the completion of the MEPA process
- Copies of all EOEA permits, licenses, and approvals issued for the project

CONTACT: Project Review Coordinator
Massachusetts Coastal Zone Management
100 Cambridge Street, 20th Floor
Boston, Massachusetts 02202
(617) 727-9530

The federal Coastal Zone Management Act of 1972, as amended, empowered states with approved Coastal Zone Management programs to review projects involving federal funding, federal permitting, and other federal actions proposed within the coastal zone to determine whether or not these actions are consistent with state coastal policies. Therefore, U.S. Army Corps of Engineers (ACOE) permits for construction in wetlands or for dredging or dredged material disposal cannot be issued until the project is determined to be consistent with the MCZM Program, and the ACOE is so informed.

To expedite the federal consistency review process, dredge project plans should be designed in accordance with MCZM Policies and other applicable state environmental regulations. It is, therefore, imperative that project proponents contact appropriate MCZM staff early in the planning stage to secure technical assistance with project design and standards for consistency.

To be subject to federal consistency review:

1. The project must be located within or must directly affect the Massachusetts coastal zone. The Massachusetts coastal zone is defined as:

    "land and waters within the area bounded by the seaward limit of the state's territorial sea (i.e. 3 miles from the baseline - see fig. 5.1)... and landward to 100 feet inland of specified major roads, rail lines, or other visible rights-of-way..." (Massachusetts Coastal Zone Management Program, p.14). A detailed road-by-road definition of the MCZM boundary is included in the publications; Massachusetts Coastal Zone Management program, 1978, and; Massachusetts Coastal Regions and an Atlas of Resources (Chapter 5.). Both publications are available for review at the MCZM Office and at town halls or libraries in coastal communities.

For assistance in determining if a project is located within, or affects, the coastal zone, contact the MCZM Office.

In unusual cases, projects outside the coastal zone might be subject to federal consistency review if the project is expected to have direct impacts on the coastal zone (and assuming that criteria 2 and 3 below are met as well). For example, a project technically outside the coastal zone but potentially affecting an anadromous fish run in a coastal community might be subject to this review. As another example, the disposal of dredged material at an ocean site beyond the three mile limit jurisdiction is subject to consistency review if it is determined to have an impact on fisheries resources, state water quality, or the state's economy.

2. The project must also involve a federal action. Virtually all dredging and navigation improvement projects involve a federal action of some type. The U.S. Army Corps of Engineers, for example, issues permits or licenses, provides funding, and/or conducts dredging and related projects for individuals, communities, or in conjunction with state agencies. Any of these licenses, permits, or other actions may be subject to MCZM federal consistency review if the project meets criterion 1 above and, in most cases, criterion 3.

3. A Massachusetts Environmental Policy Act (MEPA) review is required for the project. If the project exceeds any MEPA threshold (and meets the provisions of criteria 1 and 2), the project will be subject to federal consistency review by MCZM. The Office can, however, assert jurisdiction over a project irrespective of MEPA jurisdiction and their thresholds of review, if the proposed project or activity is considered to have the potential for significant impact to the coastal zone.

Again, criteria 1 and 2 must always be met, criterion 3 must usually be met in order to be subject to a federal consistency review by MCZM.

## HOW TO FILE

Contact MCZM for technical/planning assistance and to determine whether the project will be subject to federal consistency review. Then submit to MCZM:

- A copy of the project application, and all supporting documents, submitted to the federal agency

- A copy of the Secretarial Certification from MEPA that an EIR is not required or that the EIR is adequate

- Supporting project documentation (i.e.. plans, maps, geological, chemical, biological test results, etc.), and a detailed description of the proposed activity and its associated facilities which is adequate to permit an assessment of their probable impacts to the coastal zone

- Certification of federal consistency (a copy should also be sent to the federal agency involved in the project). This is a document, produced by the project proponent, identifying all relevant policies (as stated in the Massachusetts Coastal Zone Management Plan and supporting documents) and explaining how the proposed project is consistent with each of the applicable policies.

REVIEW PROCESS

- Upon receipt of all of the required material cited above, the MCZM Office will publish a public notice of its formal review in the MEPA Environmental Monitor.

- Upon publication in the Monitor a 21 day public comment period begins during which comments regarding the project will be received. No decision can be issued by the MCZM Office until the close of the period for public comment.

- If the MCZM Office has not issued a decision within 3 months of the commencement of its review, it will notify the applicant and the federal agency of the status of the review and the basis for further delay. In all cases, the MCZM Office will issue its decision within 6 months of the commencement of its review.

- If the MCZM Office objects to the consistency certification, the federal agency involved may not issue with its permit, license, or funding until the objection is removed by MCZM.

- The MCZM Office will notify the applicant and federal agency of the objection and will describe how the proposed activity is inconsistent with specific MCZM policies. MCZM will suggest alternative measures (if they exist) which would permit the proposed activity to be conducted in a manner consistent with MCZM Policies. If the objection is based on the failure of the applicant to supply adequate information, the MCZM Office will specify the nature of the information requested and the reasons for requiring such information.

- Objection to a certification may be removed by project modification or through an appeals process.

- The federal consistency review is concluded when MCZM issues its final "concurrence with" or "objection to" the applicant's certification of federal consistency.

NOTE: MCZM cannot conclude its review until all applicable (or required) EOEA permits, licenses, certificates, or other authorizations are issued by the respective agencies and copies are received by MCZM. To expedite MCZM review, copies of all EOEA authorizations should be sent to MCZM as they are issued.

## STATE AGENCIES: OTHER RELEVANT PROGRAMS AND POLICIES

There are a number of other agencies of the Commonwealth which have an interest, either regulatory or advisory, in the fine art of dredging and dredged material disposal. Their interest may be:

passive - where they administer a program which acts to regulate or control activities including, but usually not limited to, dredging... but no permit, license or other authorization is necessary (e.g. DEM-Ocean Sanctuaries Program, DEQE-Wetlands Restriction Program)

active but restricted - where the program requires a permit or license but is applicable to only a specific type of dredging project (e.g. DEQE-DSW Upland Disposal Site Approval). or,

advisory - where an agency responsible for a specific part of the Commonwealth's program of environmental protection and regulation (e.g. Natural Heritage and Endangered Species Program, or Division of Marine Fisheries) and is, therefore, best suited to review relevant aspects of a particular project.

In general, if there is any question at all as to whether a particular program is involved or and agency must be consulted, it it always best to call the agency and ask. When you call, it is in your best interest to provide the agency all the information that it needs to give you a decision. When you call, try to avoid phrases like "I have this friend..." and "let me give you a hypothetical example..." - the project either is or is not under the jurisdiction of that agency or program...being "cagey" or withholding important information will do little to change this basic fact (and may give the agency a bad first impression- or reinforce an old bad impression- if you do have further business with them).

What follows is as complete a list as is possible to collect of agencies and programs which may have more than a passing interest in some aspect of dredging and dredged material disposal. Their potential involvement is clearly marked as to their type and level of interest (see above), their source of jurisdiction, and a brief description of what the program is all about and how to interact with them should you be required to do so.

### DEQE - Division of Wetlands and Waterways Regulation

Permit: None Required

Authority: Massachusetts Coastal Wetlands Restriction Act M.G.L. c. 130, s. 105, and 302 CMR 4.00 - 4.19 (program regulations)

Interest: passive

Program Description: While the State Wetlands Protection Act (M.G.L. c. 131, s. 40) and local wetlands protection by-laws regulate projects proposed in wetlands areas on a case by case basis, the Massachusetts Wetlands Restriction Program controls the development of significant wetlands resource areas through enacting permanent Orders of Restriction. These Wetland Orders of Restriction (so-called "Restriction Orders") significantly limit the types of activities that can occur within that resource area on that parcel. Ownership rights are not affected by these restrictions, which are designed to guide land use towards the promotion of public health, safety and welfare; and the protection of public and private property. wildlife and marine fisheries.

Wetlands areas are evaluated for restriction and mapped by the program staff. After a public hearing, specific areas are restricted. The Order of Restriction is recorded in the appropriate County Registry of Deeds where a marginal notation is made either on the deed of a recorded parcel or the Land Court Certification of a registered parcel that all or a portion of that parcel is subject to the Restriction Order.

The Orders, which may vary in content from community to community, generally prohibit large scale alterations such as filling, dredging and discharge of pollutants within protected resource areas. Permitted activities generally include agriculture and aquaculture; building and maintenance of docks and piers, upkeep of existing roads, marine channels and structure that are erected on pilings.

Contact the Wetlands Restriction program to determine if the proposed activity is located in a restricted wetland, and if so, what restrictions have been placed on the area.

ADDRESS

DEQE - Division of Wetlands and Waterways Regulations
Wetlands Restriction Program
1 Winter Street
Boston, MA 02108
617-292-5517

DEQE - Division of Solid Waste Management

Permit: Waste Disposal Facility, Landfill/Upland Dredged Material Disposal Site Plan Approval

Authority: M.G.L. c.111, s.150A: Regulations for the Disposal of Solid Wastes by Sanitary Landfill, 310 CMR 19.00, 310 CMR 30.00 (E.P Toxicity)

Interest: regulatory but restricted

Program Description:

The Solid Waste Regulations are intended to provide effective criteria and methodology for the approval of sanitary landfills for solid waste disposal. In the Commonwealth of Massachusetts, material is considered a solid waste if it is non-hazardous, contains no less than 18-20% solids, and contains no free draining liquid. Dredged and excavated sediments are non-hazardous if: 1) they contain less than 50 ppm polychlorinated biphenyls, 2) EP Toxicity limits, as defined in 310 CMR 30.00, are not exceeded, and 3) "Oil and Grease" content of the sample (see page 6-4 for further description of this test) must not exceed 3%. If the material is found to be non-hazardous and meets the additional criteria cited above, it is classified as solid waste and is subject to 310 CMR 19.00, "Disposal of Solid Wastes by Sanitary Landfill". Either the local Board of Health or the DSW will review any application for upland disposal of non-hazardous material depending on which agency made the original site assignment.

The concentrations of contaminants in the dredged material, pursuant to 314 CMR 32.00, will determine whether the material can be used only for sanitary landfill cover or as "clean fill" (see Figure 3.1). If so designated, the placement of the fill is far less restricted, assuming that it meets other appropriate standards and policies. In this regard, given recent changes in DEQE-DWPC policy (see Figure 3.2), most marine sediments will not meet the sodium and chloride standards set in the regulations. Therefore, without some form of treatment, the dredged material from most coastal projects must be considered unsuitable for upland disposal. However, if the sediments are from the freshwater end of an estuary or from some other freshwater source, it may be advantageous to contact DSW to determine if upland disposal is a possibility. See Figure 3.2 or contact DWS directly for additional guidance regarding upland disposal options and requirements.

ADDRESS:

DEQE - Division of Solid Waste Management
1 Winter Street
Boston, Massachusetts 02108
617-292-5960

Permit: No permit required

Authority: Massachusetts General Laws c. 21 A, s. 2(7); St. 1974, c. 40(e); 301 CMR 12.00

Interest: passive

The Area of Critical Environmental Concern (ACEC) program was established in recognition of the fact that certain land and water resources are of such limited nature or central importance that the protection and management of these resources transcends purely local concerns. In the words of the statute and regulations, it must be an "area of critical environmental concern to the Commonwealth", containing resource attributes of "regional, state, or national importance" or "significant ecological systems with critical relationships among a number of components".

Upon designation, the area is subject to a higher level of protection and closer scrutiny of proposed projects. The program is administered through MCZM but implemented in existing State regulations. For example:

- Wetlands Protection Act: standard raised from "minimize adverse impacts" to "no adverse impacts" for all protected resource areas, with the exception of maintenance dredging in "land under the ocean".
- Waterways Licensing Program: prohibits improvement dredging in ACEC areas as well as limits opportunity for disposal of dredged materials...restricts where maintenance dredging can occur in ACEC.
- DEQE Water Quality Standards: calls on DWPC to reclassify waters of ACEC to highest water quality standards and incorporate strict anti-degredation standards.
- DEQE Wetlands Restriction Program: restricts all appropriate wetlands within 15 months of designation.

A list of the nine coastal ACEC's designated as of this printing is presented in Figure 5.2

## HOW TO FILE

There is no filing required...if the project is situated within an ACEC, certain special provisions apply in other State regulations (as discussed above).

## ADDRESS

Massachusetts Coastal Zone Management
100 Cambridge Street, 20th Floor
Boston, Massachusetts 02202
(617) 727-9530

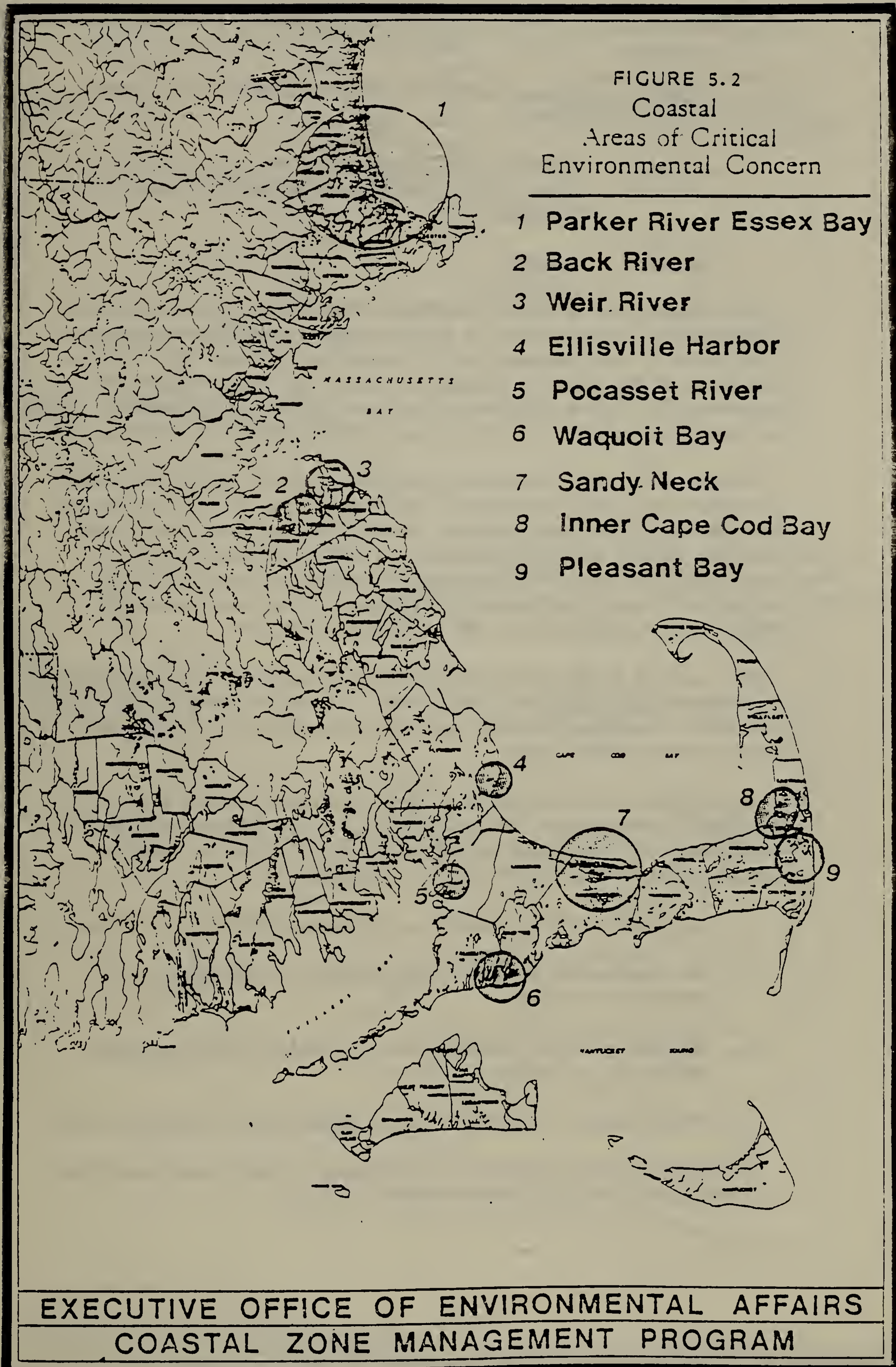


FIGURE 5.2
Coastal
Areas of Critical
Environmental Concern

Permit: Ocean Sanctuaries Program approval (no formal permit)

Authority: Massachusetts Ocean Sanctuaries Act, M.G.L. c. 132A, s. 13-16, 18; Ocean Sanctuaries Regulations, 302 CMR 5.00

Interest: passive

The purpose of the Ocean Sanctuaries Program is to protect the five Massachusetts' ocean sanctuaries from any exploitation, development or activity which would seriously alter or otherwise endanger the ecology or appearance of the ocean, the seabed, or subsoil of the seabed, or the Commonwealth waters adjacent to the Cape Cod National Seashore. Figure 5.3 shows the boundaries of the currently designated Ocean Sanctuaries.

Because the Ocean Sanctuaries Act states that the Department "shall not require any additional permits," the Department acts as a trustee of the resources of the ocean sanctuary rather than as a permitting agency. Thus, for specific activities located in an ocean sanctuary, the department will confer with licensing and permitting agencies of the Executive Office of Environmental Affairs to ensure that the activity is conducted in accordance with the provisions of the Act.

The policies of the Ocean Sanctuaries program reflect the goals of the Massachusetts Coastal Zone Management Program including the protection of ecologically significant resource areas and supporting the attainment of national water quality goals.

Prohibited activities in the five ocean sanctuaries, except as specifically allowed under Sections 8.1 - 8.9 of the Ocean Sanctuaries Regulations, that involve or may affect dredging or dredged material disposal activities include but are not limited to:

a. the building of any structure on the seabed or under the subsoil;

b. the construction or operation of offshore or floating electric generating stations;

c. the removal of any minerals, such as sand or gravel, and the drilling for oil or gas;

d. the dumping or discharge of any commercial or industrial wastes.

Allowable activities which involve dredging or which may be affected by dredging and dredged material disposal include:

FIGURE 5.3
Ocean Sanctuaries of Massachusetts as defined by M.G.L.C. 132A ss. 13-16 and 18
North Shore Ocean Sanctuary
South Essex Ocean Sanctuary
MASSACHUSETTS BAY
Cape Cod Ocean Sanctuary
Cape Cod Bay Ocean Sanctuary
CAPE COD BAY
BUZZARDS BAY
NANTUCKET SOUND
Cape and Islands Ocean Sanctuary
Commonwealth of Massachusetts
Executive Office of Environmental Affairs
COASTAL ZONE MANAGEMENT

a. projects authorized under M.G.L. c.91, including channel and shore protection projects and navigation aids only if they are not otherwise prohibited by the Ocean Sanctuaries Regulations and if they have received state and federal approvals;

b. any improvement or uses that are not specifically prohibited by ss. 14, 15, and 18 of the Ocean Sanctuaries Act so long as they don't change or extend such structures or uses and otherwise approved by appropriate state and federal agencies. Such improvement may change or extend such structures if it is specifically permitted by ss. 8.1 -8.9 of the Ocean Sanctuaries Regulations..

HOW TO FILE

- Contact the Ocean Sanctuaries Coordinator to determine whether your project is located in an Ocean Sanctuary. If the project is located in an ocean sanctuary, submit to the Coordinator:

  - a copy of the Environmental Notification Form (ENF) submitted to MEPA:

  - copies of all license and permit applications submitted to state and federal permitting agencies.

REVIEW PROCESS

Upon notification that an activity is proposed is an ocean sanctuary, the Ocean Sanctuaries Coordinator will:

- Initiate informal discussions with state licensing and permitting agencies to insure that the activity will be conducted in accordance with the Ocean Sanctuaries Act.

- If the Department finds that informal discussions fail to reconcile any differences with the licensing and permitting agency, and the agency is within the Executive Office of Environmental Affairs (EOEA), the Department will ask the Secretary of EOEA to resolve the conflict.

- It is the responsibility of all state agencies to issue, deny, or condition permits or licenses or to conduct their activities in a manner consistent with the provisions of the Ocean Sanctuaries Act.

ADDRESS

Department of Environmental Management
Ocean Sanctuaries Program
100 Cambridge Street
Boston, MA 02202
617-727-3260

DEPARTMENT OF FISHERIES, WILDLIFE, & ENVIRONMENTAL LAW ENFORCEMENT,
Division of Marine Fisheries

Permit: Division of Marine Fisheries project approval (no formal permit)

Authority: Marine Fisheries Regulations M.G.L. c.130, s. 1-104, 322 CMR 1.00 through 322 CMR 11.00

Interest: advisory

The function of the Division of Marine Fisheries is to manage the manner of taking fish; legal size limits of fish to be taken; the seasons and hours during which fish may be taken; the numbers of quantities of fish which may be taken; and the opening and closing of areas to the taking of fish.

The Division also reviews proposals for coastal activities to provide state licensing and permitting agencies with recommendations for the reduction, mitigation, and, if possible, elimination of adverse impacts to marine resources, promote maintenance dredging of fishing ports, and prevent hazards to navigation. The Division also takes part, when requested, in the review process of the U.S. Army Corps of Engineers Section 10, Section 404 Permit program in order to protect the marine environment and resources from harmful effects of coastal alteration, dredging or ocean dumping.

REVIEW PROCESS

- Projects are reviewed on a case by case basis.

- The DMF review is based upon the resources involved, the time of the year that the activity will occur, and the location of the area where the activity will take place.

  Areas of critical concern to the Division include fish and shellfish habitat, spawning and nursery areas, and active fishing grounds. Impacts to water quality and the resultant effects to fish and shellfish habitat, health, and productivity are also reviewed and recommendations for the regulation of those impacts are provided for the state licensing or permitting agency.

ADDRESS

Department of Fisheries, Wildlife, & Environmental Law Enforcement
Division of Marine Fisheries
100 Cambridge Street, 19th Floor
Boston, Massachusetts 02202
617-727-3194

Permit: No permit required

Authority: Massachusetts General Law Chapter 131, Section 4(13)(a); 321 CMR 8.00 (State Rare and Endangered Species Lists)

Interest: advisory

The primary focus of the Natural Heritage and Endangered Species Program (NHESP) is the the inventory and conservation of endangered, threatened, and special concern plant and animal species occurring in the Commonwealth. The program maintains a comprehensive, statewide data base containing the locations and status of the Commonwealth's rarest and most vulnerable natural features. The NHESP uses this information base to encourage the protection and conservation of sites which harbor these important species, and to promote the preservation of natural areas.

The program also reviews applications for state and federal permits for possible encroachment of development on known endangered, threatened, and special concern species habitat, and assists state agencies in various tasks with their expertise in this area.

There is no formal application process but the NHESP should be consulted directly if there is any question concerning a particular project and conflicts with protected species.

ADDRESS

Department of Fisheries, Wildlife, & Environmental Law Enforcement
Natural Heritage and Endangered Species Program
100 Cambridge Street, 19th Floor
Boston, Massachusetts 02202
(617) 727-9194

## BOARD OF UNDERWATER ARCHAEOLOGICAL RESOURCES

**Permit:** No formal permit required, unless underwater archaeological resources are to be disturbed, removed, or destroyed.

**Authority:** Massachusetts G.L. c. 6, s. 179-180; c. 9, s. 26; c. 12, s. 11D; c. 30, s. 61; c. 91, s. 63 and 72; Chapter 989 of the Acts of 1973; and, 312 CMR 2.00

**Interest:** advisory/regulatory (depending on the activity and resources affected).

While the regulation of dredging and dredged material disposal may seem far from the purposes of the Board of Underwater Archaeological Resources (BUAR), there is a very direct link to this type of activity. Given that dredging and disposal activities involve the excavation and relocation of sediment, the potential exists for a significant amount of disturbance to an underwater archaeological site from a dredge and fill operation. Considering the maritime history of Massachusetts and the amount of coastal dredging that occurs, there is little question that important sites have been disturbed or destroyed by dredging or disposal.

In most cases, the BUAR's interest in dredging is limited to review of proposed projects. However, if underwater archaeological resources are affected, a permit from the Board is required. Underwater archaeological resources are defined as abandoned properties, artifacts, treasure troves, or sunken ships which have remained unclaimed for 100 years or more, or are determined to have a value of five thousand dollars or more, or judged by the Board to have historical value.

### ADDRESS

Board of Underwater Archaeological Resources
100 Cambridge Street, Room 2006
Boston, Massachusetts 02202
(617) 727-9530

## FEDERAL AGENCIES: CORPS OF ENGINEERS

PERMIT: Section 10, Section 103, Section 404

AGENCY: U.S. Army Corps of Engineers, New England Division

AUTHORITY: Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403); Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (Ocean Dumping Act, 33 USC 1413); Section 404 of the Clean Water Act (PL 92-500, 86 Stat. 816, 33 USC 1344)

JURISDICTION: Any construction or dredge/fill activity seaward of mean high water (see table in detailed description)

FEE: $10 for non-commercial, $100 for commercial activities

REVIEW PERIOD: Typically 2-4 months after the receipt of a completed application for non-controversial projects

PREREQUISITES: Applicants must receive federal consistency concurrence from MCZM and a Water Quality Certificate from the DEQE/DWPC, when there is a discharge of dredged or fill material, before the Corps will issue any permit

TIMING: Prior to Construction PERMIT LIFE: Unlimited

RENEWAL: Section 103 requires a new application for each maintenance dredging project

DOCUMENTATION:
- Completed application (Form 4345)
- plans and maps in sufficient detail to describe the area to be dredged and disposal area (see "How to File")
- discussion of potential environmental impacts
- appropriate environmental testing (see Chapter 6 for details)
- copies of any permits and licenses or other authorizations already received of applied for

CONTACT: U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254-9194
(617) 647-8338

## DETAILED DESCRIPTION: CORPS OF ENGINEERS

The Corps of Engineers is the primary regulatory agency of the federal government in matters pertaining to dredging and dredged material disposal in navigable waters of the United States. The major thrust of Corps regulatory activity is threefold: 1) to prevent the unauthorized alteration or obstruction of a navigable waterway; 2) to protect water quality; and, 3) to control the discharge of dredged materials into ocean waters. As the lead federal agency, the Corps is not only responsible for the issuance of the permit, but must also coordinate the review of projects by other participating federal, state, and local agencies as well as allow the opportunity for comments from the general public.

The regulatory authority of the Corps rests in three major pieces of legislation. Section 10 of the Federal Rivers and Harbors Act of 1899 states that dredging from or disposal of material into navigable waters of the United States, or the construction of any project which affects the course, location, condition, or capacity of those waters requires a permit from the Corps of Engineers. Section 404 of the Federal Water Pollution Control Act (Clean Water Act) authorizes the Corps to issue permits for the disposal of dredged or fill materials into waters of the United States. Similarly, Section 103 of the Ocean Dumping Act authorizes the Corps of Engineers to issue permits for projects involving the transportation of dredged material for disposal in ocean waters.

There are a number of different types of permits, the one appropriate to a particular project will depend on its scope and complexity. Individual Permits are those which are issued for a specific project and require extensive review by the various coordinating agencies...most larger dredging projects fall into this category. General Permits may be issued by the District Engineer when a project falls into a generic category of activities which are known to (or at least assumed to) not have any significant adverse impacts. These are limited to specific geographic regions and require less copious application materials. A general permit has been issued to cover maintenance dredging in Massachusetts that does not exceed 10,000 cubic yards and disposal is limited to former or existing landfills, borrow areas, dredged material disposal sites, and other previously disturbed sites or used as beach nourishment. Last but not least are Nationwide Permits, which do not require application or review if the project falls into a very specific set of conditions. At the present time, MCZM has objected to the Nationwide Permits associated with dredging (#18-19). In any case, the applicant must receive federal consistency from MCZM and a water quality certificate from DEQE/DWPC if open water disposal is proposed. It would, therefore, be unwise for proponents to assume that their project is covered by a Nationwide Permit without checking first with MCZM and the Corps.

Type or magnitude of project notwithstanding, it is important to contact the New England Division District Engineer so that appropriate applications can be made and proper permits secured.

The following (after "Table 5" of Clar and Hutchins 1983) is a listing of typical activities which require a Corps Permit:

| | | |
|---|---|---|
| Artificial Canals | Artificial Islands | Dolphins |
| Beach Nourishment | Boat Ramps | Dredging |
| Breakwaters | Bulkheads | Filling |
| Dams, Dikes, Weirs | Groins and Jetties | Levees |
| Mooring Buoys | Ocean Dumping | Discharging: |
| Outfall Pipes | Piers and Wharves | Sand, Gravel, Clay |
| Riprap | Road Fills | Stone, Mud, Silt |
| Signs | Tunnels | other Sediments |

<u>HOW TO FILE</u>

Submit to the Corps of Engineers:

- A completed Engineer Form 4345, or the joint federal/state Notice of Intent form which is submitted to the local Conservation Commission under the Wetlands Protection Act. This form requests a complete description of the project, names and addresses of adjoining property owners, and detailed information regarding location, and names of waterways affected by the project;

- A list of the status of all federal, state, and local licenses, certificates, permits and approvals, along with a copy of each permit application or permit (if issued). This must include a copy of the application to the DEQE-Division of Water Pollution Control for a Water Quality Certificate (see pp. 5-25 to 5-25). If any permit, license or other authorization has been denied by another governmental agency, an explanation of the reasons for that denial should be included.;

- A detailed description of the proposed work, including the purpose, use, types of structures, types of vessels that will use the facility, facilities for handling wastes and the type, composition, and quantity of dredged material;

- One set of original or good quality reproducible drawings on 8 1/2 x 11" sized cloth, film, or paper. Contact the Corps to identify drawing specifications. The set should include a locus map (which identifies the project by street, town, etc.), a plan view (including existing shorelines, high and low water lines, water depths, waterward dimension from a fixed structure, etc.), and an elevation and/or cross sectional view;

- A consistency statement (statement that the project is consistent with the Massachusetts Coastal Zone Management Program Policies - see previous section "State Agencies: EOEA-Office of Coastal Zone Management").

- A description of alternatives to fill projects.

THE REVIEW PROCESS

- After receipt of completed application and acceptable plans, the Corps will issued a public notice of the project to local, state, and federal agencies, interest groups, and individuals. The public notice will describe the project and its location and it will include reproductions of maps, project diagrams, and cross sections that are submitted with the application. The public notice will advertise the public comment period (not less than 15 days nor more than 30 days...typically the maximum comment period is selected) and where to send comments.

- The Massachusetts Coastal Zone Management (MCZM) Office will review the federal permit for consistency with MCZM program and polices (see pp. 5-26 to 5-29).

- The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, the National Marine Fisheries Service and other appropriate agencies will review the project in cooperation with the Corps to determine its compliance with their relevant federal statutes and regulations.

- These agencies may recommend permit conditions regarding such issues as dredging methods and permitted disposal site locations, or recommend denial of the permit. EPA is authorized to veto the Corps decision to allow the discharge of dredged material in waters of the U.S. if the project does not, in their judgement, comply with provisions of the Ocean Dumping Act and Clean Water Act. If the Corps and the federal agencies cannot reach a mutual understanding on a particular permit action at the District level, the matter can be elevated to the division level or officials in Washington, D.C. for final resolution.

- Once a decision is made to approve or deny the permit, the applicant will be forwarded two copies of the permit form to sign and return one copy to the Corps of Engineers with applicable fees.

Like the additional state agencies lumped together into the category "other programs", there are a number of federal agencies which have a regulatory or advisory role regarding the activity of dredging and dredged material disposal. All project review at the federal level is coordinated by the Corps in a process known as "interagency review". These are meetings where all the relevant agencies meet at the NED Headquarters in Waltham to discuss projects of particular interest. After these meetings, the agencies return to their respective offices and generate written comments to be submitted to the Corps.

Included in this section are the major federal agencies which normally become involved with the review of dredging projects. The bulk of this information and the attached figures are taken from Clar and Hutchins (1983) Maryland Dredge and Fill Permit Process Handbook, an excellent reference document put together for the Maryland Coastal Zone Management Office.

## U.S. ENVIRONMENTAL PROTECTION AGENCY

**Permit:** No formal permit

**Authority** Federal Water Pollution Control Act as amended [33 U.S.C. 1251 et seq., Section 401-405, especially 404(b)/40 CFR 230 and 404(c)/40 CFR 231]..National Environmental Policy Act of 1969 [42 U.S.C. 4321-4347, Section 102]...Marine Protection, Research and Sanctuaries Act of 1972, [40 CFR 220]

**Interest** Can assert significant regulatory authority but role is mostly advisory

The primary focus of the EPA is to control the discharge of dredged material to ensure that the chemical, physical and biological integrity of the waters of the United States is maintained and/or restored.

The Clean Water Act authorizes EPA to co-review Corps 404 permit applications to determine whether the project is in compliance with federal law before the permit is issued. If the EPA determines that the project will have a significant environmental impact to selected environmental values, it has the legal authority to veto the issuance of the Corps permit. The Act further empowers EPA to prohibit or restrict the use of any area as a discharge site whenever it determines that, after public notice and hearings, such discharge will have an unacceptable adverse effect on factors such as municipal water supplies, shellfish beds, fishing grounds (including spawning and breeding grounds), and recreational areas.

The EPA also has the responsibility for the authorization of ocean disposal sites. Those proposed sites which are located in waters seaward of the established baseline must be federally "designated under procedures outlined by the U.S. Environmental Protection Agency or at a site selected by the District Engineer of the Corps" (40 CFR 228, 5-6). Procedures used in disposal site designation include extensive physical, chemical, and biological evaluations of the ecosystem at the disposal site to evaluate the potential for the site to assimilate dredged material.

The EPA can, much like its veto authority for Section 404 permits, prevent the issuance of a Section 103 permit from the Corps for a specific disposal project if it determines that the dumping of the dredged material will result in an unacceptable adverse impact on factors such as fisheries, human health, or marine ecosystem diversity, productivity, or stability. This determination is made, in part, on the basis of the results of physical, chemical and biological testing of the dredged material and an analysis of the potential impacts of these sediments at the disposal site.

ADDRESS

United States Environmental Protection Agency
Wetlands Protection Section
JFK Building
Boston, MA 02203
(617) 565-3347

U.S.FISH AND WILDLIFE SERVICE

Permit: No formal permit required

Authority: Fish and Wildlife Coordination Act [16 U.S.C. 661-667(e)]...Fish and Wildlife Act of 1956 [16 U.S.C. 742(d)-754]...National Environmental Policy Act of 1969 (NEPA) [42 U.S.C. 1451-1464]...Federal Water Pollution Control Act, as amended [33 U.S.C. 1251 et seq.]...Estuary Protection Act [16 U.S.C. 1221-1226]...Coastal Zone Management Act of 1972 [16 U.S.C. 1451-1464]...Wild and Scenic Rivers Act [16 U.S.C. 1272-1287]

Interest: predominantly advisory

The U.S. Fish and Wildlife Service (FWS) is a major participant in federal permit application review. The FWS is responsible for the assessment of impacts on fish and wildlife resulting from all water and land related resource development projects, especially those proposed for wetland areas, which are federally funded or require a federal permit or license.

While it appears that lawmakers in Washington seem to have a penchant for including FWS in environmental legislation, the bulk of their review authority comes from the Fish and Wildlife Coordination Act of 1958 which established the agency and gave it environmental review authority. While FWS can recommend denial of an application for a Corps permit, the Corps is not required to accept their recommendation...though, as a practical matter, any recommendation for denial from a coordinating agency significantly decreases the chances for approval by the Corps.

ADDRESS

U.S. Fish and Wildlife Service
Northeast Region
One Gateway Center, Suite 700
Newton Corner, Massachusetts 02158
(617) 965-5100

## NATIONAL MARINE FISHERIES SERVICE

Permit: No formal permit required

Authority: While the NMFS operates under more than fifty specific authorities, the eight most relevant to dredging are: Fish and Wildlife Act of 1956 [16 U.S.C. 742(a)-742(k), 661-666(c)]...Commercial Fisheries Research and Development Act of 1964 [16 U.S.C. 779-779(f)]...Endangered Species Act of 1973 [16 U.S.C. 1531-1542]...Anadromous Fish Conservation Act of 1965 [16 U.S.C. 757(a)-757 (f)]...Marine Migratory Sport Fish Act of 1959 [16 U.S.C. 760(e)-760(g)]...Fishery Conservation and Management Act of 1976...Marine Protection, Research and Sanctuaries Act of 1972 [Titles I and II]...National Environmental Policy Act of 1969.

Interest: Advisory

The central role of the National Marine Fisheries Service (NMFS) is to maintain a viable commercial and recreational marine fishery for the benefit of all present and future U.S. citizens. The focus of this effort which is most relevant to dredging and dredged material disposal is the protection and/or enhancement of marine fisheries habitat, areas upon marine fish and other harvestable species depend for spawning, nursery and feeding. To this end, the branch of NMFS responsible for maintaining

environmental integrity uses this broad spectrum of statutory authority to insure that all decisions regarding actions taken in the coastal zone give full consideration to potential adverse impacts to fisheries habitat.

While NMFS has not published regulations regarding dredging and dredged material disposal, the Northeast Regional Office has provided some informal guidance in the form of Figure 5.4 (adapted from Clar and Hutchins 1983).

ADDRESS

National Marine Fisheries Service
2 State Fish Pier
Gloucester, Massachusetts 01930
(617) 281-3600

## NATIONAL PARK SERVICE

Permit: No formal permit required

Authority: Congressional action which established the NPS on 25 August, 1916 [16 U.S.C. 1]...National Environmental Policy Act of 1969

Interest: Advisory

The National Park Service (NPS) is involved in the permit review process for dredging and dredged material disposal only on those projects involving park lands. In Massachusetts coastal waters, the primary NPS interest would be any project within or directly affecting the Cape Cod National Seashore.

ADDRESS

National Park Service
Northeast Regional Office
15 State Street
Boston, Massachusetts 02109
(617) 223-0058

FIGURE 5.4 INFORMAL GUIDANCE: NATIONAL MARINE FISHERIES SERVICE, NORTHEAST REGION, GENERAL RESPONSE TO WATER-RELATED PROJECTS REQUIRING FEDERAL PERMITS

Each project has unique characteristics, thus criteria cannot be developed for all situations. The following guidelines are generalities based upon past experiences. Our final recommendations are based upon specific site and project situations.

1. The National Marine Fisheries Service, Northeast Region (NMFS/NE) encourages the following:
   a) Stabilization of eroding shorelines with vegetation, gabions or rip-rap.
   b) Dredged material deposition in confined upland areas.

2. NMFS/NE usually does not object to issuance of permits for the following:
   a) Private mooring buoys.
   b) Private piers that do not encroach upon public shellfish grounds.
   c) Open-pile-type marinas located in areas where tidal circulation is adequate to maintain good water quality, and where extensive dredging is not required. Marinas should also avoid locating near shellfish beds, and provide sewage pump-out facilities.

3. NMFS/NE usually discourages the following:
   a) Open-water dredged material disposal
   b) Dredging in marine and estuarine areas. However, if dredging is deemed necessary, dredged areas should be connected to adjacent bottom contours of equal or greater depth to promote circulation and prevent sump formation.

4. NMFS/NE usually recommends permit denial for the following:
   a) Filling of wetlands or open water to create fastland.
   b) Bulkheads located channelward of the mean high water line, unless special circumstances require such placement
   c) Marinas located in or near productive shellfish beds or in areas where tidal circulation of water is minimal.
   d) Dredging of marsh, shellfish, and seagrass beds.
   e) Dead-end canals.
   f) Dredging for fill or borrow material.
   g) Structures, such as tide gates or dikes, which impede circulation of tidal water over wetlands

FIGURE 5.4 (CONTINUED)

## NMFS/NE REVIEW CONSIDERATIONS

NMFS/NE suggest you consider the following items when initially planning your project.

1. Alternatives: have you considered alternative project locations or designs that will meet your objectives with a minimum of disruption to marine or estuarine waters. For example, in many cases instead of encroaching upon wetlands or shallow open waters, a bulkhead can be placed at the base of an eroding bank, thus minimizing the loss of marine habitat and living resources.

2. Water-dependency: Can your project be located elsewhere or must it be located on the water's edge?

3. Public Interest: A project may affect various public resources, including fisheries or associated habitat, either positively or negatively. Will your project provide long-term benefits to the community, such as increased employment, improved public water access or protection of public health and safety?

Generally, if the above items are met, you should have little difficulty in obtaining authorization to construct your project. However, if public fishery resources will be lost as a result of project construction, we may want to discuss additional alternatives or recommend to the Corps of Engineers that compensation be considered to offset the lost resources or habitat.

Compensation will be tailored to the particular site and project, and may consist of: replacement in-kind (i.e. conversion of uplands to marsh or shallow water); restoration of existing habitat that has been degraded; or enhancement of habitat to improve its biological productivity or carrying capacity.

U.S. COAST GUARD

Permit: No formal permit required.

Authority: Section 9 of the River and Harbor Act of 1899

Interest: Regulatory and advisory

The Coast Guard has authority and responsibility for issuing permits to construct bridges or causeways in "navigable waters of the United States", as required under Section 9 of the River and Harbor Act of 1899. Given that such construction may be associated with dredging and dredged material disposal, it has been included here.

ADDRESS

U.S. Coast Guard
First Coast Guard District
427 Commercial Street
Boston, Massachusetts 02128
(617) 223-3675

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## ENVIRONMENTAL TESTING REQUIREMENTS: MEETING THE CRITERIA

The environmental testing requirements for dredging projects is, in many cases, the most expensive and time-consuming aspects of the regulatory process. Given the rather technical and scientific nature of the activity, there is little the "do-it-yourself'er" can do to defray the cost, unless, of course, he or she operates an environmental testing laboratory. Depending on the level of contamination of the sediments, the proposed method of disposal, and the size of the project, the bill could run well into the thousands and tens of thousands of dollars.

The bottom line is that if the project is to move forward, the appropriate testing must be done. The operative word here is "appropriate". It is to the benefit of all concerned with dredging projects, whether proponent, regulator, or consultant, to know something more than the names of the various testing options and under what circumstances should these procedures be required.

While each regulatory agency establishes its own testing requirements and protocols, and should be contacted directly for their specific requirements, in the majority of cases there is usually agreement among the principal regulators as to which tests need to be done and which protocols are appropriate. Given that the federal agencies, particularly the Corps of Engineers and the EPA, have worked together to develop mutually acceptable requirements and procedures (EPA/COE 1977), and because the state agencies have not engaged in a similar effort, it is rare, but by no means unheard of, for a regulator to refuse to accept results of a test which was performed in accordance with the federal guidelines. As will be stressed a number of times throughout this chapter, it is essential to find out, directly form the agency issuing the permit, license, or certificate as to their specific requirements.

Environmental testing for proposed dredging projects is essentially an incremental, three-tiered process starting out with a physical analysis, required for nearly every project, moving next to a chemical analysis, determining concentrations of various potential contaminants, finally leading to biological analyses such as bioassays, bioaccumulation tests, and benthic community structure analyses. An assessment is made at each level, based on the best and most complete information available, as to whether sufficient data have been collected to allow the permit decision to be made.

### A. Physical Analysis:

In terms of general information, the physical analysis of dredged material will suggest more about a particular site than any other single piece of data. The sediment is, after all, a record of the physical environment at the site. It can infer the potential for contamination, suggest which organisms might be living there, and, as mentioned above, provide some feeling for the current regime at the site and the associated forces which acted to deposit that particular material in that particular

location. While it must be strongly emphasized that this single testing procedure cannot provide specific or detailed information (except for the actual grain size analysis), defining the physical characteristics of the sediments can be instrumental in providing direction for subsequent environmental testing.

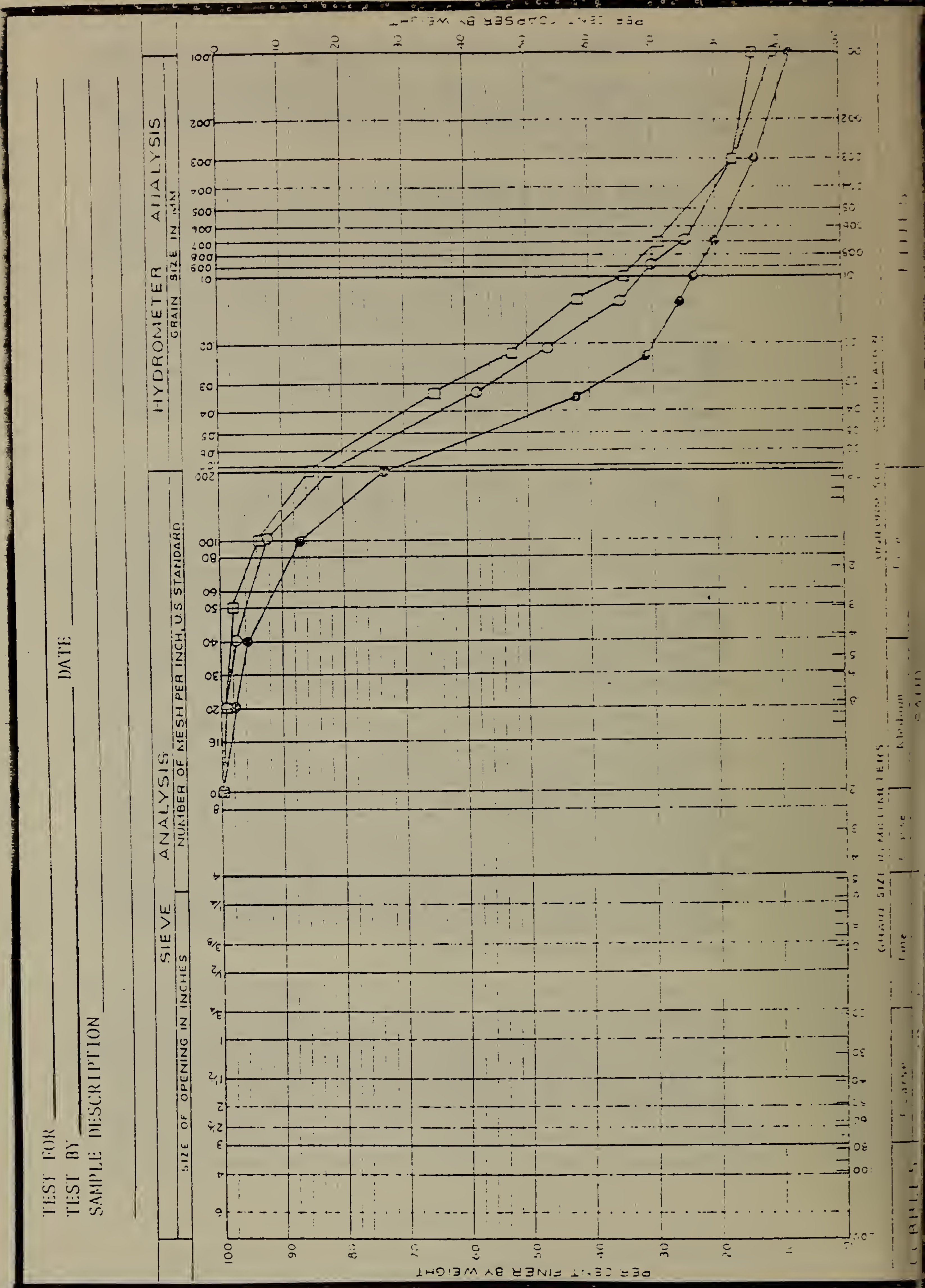
Sediment grain size analysis is the basic test for determining the physical characteristics of the material to be dredged. While there are a number of different protocols utilized in this type of analysis (ASTM 1985, Folk 1974, Sawlan and Borgeld 1976), the process generally involves, for sediments between approximately 1/16 to 16 mm, passing a known quality of the material through a series of standard geological sieves and recording what percentage of the sample is retained by each sieve. For that portion of the sample less than 1/16 mm, sedimentation techniques are used which involve the measurement of settling velocity of the material. This information is usually reported as in Figure 6-1, or presented in tabular form. It is from this analysis that the "% silt/clay" parameter required by the DEQE-DWPC is derived.

While the mode of sample collection is less critical than with other environmental testing protocols, it is important to obtain a sample that is representative of the portion of the "dredge footprint" (the outline on the bottom of the area to be dredged) being examined. A coring device which penetrates to the maximum depth of dredging would provide the best type of sample. Sampling only the sediment surface, assuming that the sampling device used will retain the top layers intact, may tend to make the dredged material appear to be more contaminated than it actually may be, given that most contaminants are concentrated in the surficial sediments. See the section following on "Sampling Design and Protocols".

Because this section deals with physical analysis and environmental testing requirements, a characterization of the physical oceanography at the dredge and disposal site, though rarely explicitly required, is vital to the planning process. If sufficient data is available from existing sources this can be used, but if not, it must be collected in the field. While this sampling and analysis is usually an expensive proposition, it is ultimately well worth the expense and effort, at least for projects which involve a significant amount of dredging. This information can be collected with a variety of current meters, for velocity and direction of currents, or by drogue or "drifter" studies. Without this information, no proper impact assessment is possible.

One other physical characteristic of the dredged material which must be measured is the "% water" content. This is generally measured by taking a known quantity of sediment, evaporating the water by drying at $80^{o}C$ then reweighing the sample for 24 hours or until no further change in weight is observed. This allows an estimate of the level of consolidation (i.e. density) of the material to be dredged.

FIGURE 6.1 PRESENTATION OF SEDIMENT GRAIN SIZE ANALYSIS



B. Chemical Analysis:

The so-called "bulk sediment analysis" is, with grain size analysis, the most commonly undertaken sampling procedure for proposed dredging projects. Once the grain size analysis has been completed, the potential for contamination is assessed. If there is any chance that the material contains contaminants in concentrations greater than trace, or background, levels, bulk sediment analysis is required. Needless to say, in Massachusetts waters, bulk sediment analyses are routinely done.

Table 6.1, "Bulk Sediment Analysis, Criteria Summary Table" provides a list of the parameters generally required by the Commonwealth agencies and NED, as well as available criteria and average regional values.

The first two parameters of interest, volatile solids and oil and grease, are somewhat generic in character. The "Volatile Solids - NED" method is somewhat different from the more standard EPA method in that it utilizes a lower temperature to "bake off" the volatile solids from the sample. The procedure generally involves placing a dried sample of known quantity in a muffle furnace at 350-400 degrees Centigrade for one hour. The precise "before and after" weights of the sample allow the "%" (wt./wt.) calculation. "Oil and Grease" is measured by extracting the hydrocarbon fraction in freon and analysing the extract by infared spectrophotometer (Plumb 1981). The results of this analysis can provide an extremely rough estimate of the concentration of hydrocarbons in the sample. While there are some difficulties in interpreting the results of these tests because of their non-specificity, useful information may be obtained nonetheless.

The so-called "heavy metals" (HM) are another component in the overall bulk sediment analysis. Various details about the metals, state and federal standards, typical concentrations, and other relevant data is included in Appendix B, "Heavy Metals Fact Sheets" and Table 6.1. HM are of concern because they have a tendency to be taken up and concentrated in the tissues of marine and estuarine organisms (see following sections on bioassays and bioaccumulation testing), which may be directly or indirectly consumed by man. In significant concentrations, HM could pose a substantial public health risk.

The last of the parameters that are typically required by either the Commonwealth or federal regulatory agencies is polychlorinated biphenyls (PCB), a by-product of industrial activity (formerly used in large electric transformers) and a known carcinogen. Of particular concern in the Acushnet River estuary, where concentrations are so high a "Superfund" site has been established, and in portions of Boston Harbor, this compound is showing up in significant concentrations in samples taken from areas that could be considered pristine in almost all other respects. The recommended procedure (EPA 1977), though perhaps not the most sensitive or allowing the greatest resolution, permits an adequate estimation of the concentration of PCB in the sample. The procedure generally involves the extraction of the material in a solvent and analysis of the extract by gas chromatograph (GC).

TABLE 6.1
BULK SEDIMENT ANALYSIS
CRITERIA SUMMARY TABLE

| PARAMETER | UNIT | ACOE TEST REQ. | MA DEQE - DWPC SEDIMENT CLASSIFICATION I | II | III | A | B | C | GULF OF MAINE TIDAL SYSTEM X | SD | EPA MARINE WATER QUALITY CRITERIA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Volatile Solids-NED | % | * | | | | <5 | 5-10 | >10 | 4.372 | 4.992 | |
| Water Content | % | * | | | | <40 | 40-60 | >60 | | | |
| Silt/Clay | % | | | | | <60 | 60-90 | >90 | | | |
| Oil and Grease | % | * | | | | <0.5 | 0.5-1.0 | >1.0 | 0.253 | 0.383 | |
| Mercury (Hg) | PPM | * | <0.5 | 0.5-1.5 | >1.5 | | | | 0.573 | 1.210 | 0.0021 |
| Lead (Pb) | PPM | * | <100 | 100-200 | >200 | | | | 83.20 | 100.8 | 0.1400 |
| Zinc (Zn) | PPM | * | <200 | 200-400 | >400 | | | | 134.5 | 151.0 | 0.1700 |
| Arsenic (As) | PPM | * | <10 | 10-20 | >20 | | | | 6.980 | 7.660 | 0.0690 |
| Cadmium (Cd) | PPM | * | <5 | 5-10 | >10 | | | | 3.120 | 6.250 | 0.0430 |
| Chromium (Cr) | PPM | * | <100 | 100-300 | >300 | | | | 112.0 | 225.4 | 0.0110 |
| Copper (Cu) | PPM | * | <200 | 200-400 | >400 | | | | 83.20 | 129.4 | 0.0029 |
| Nickel (Ni) | PPM | * | <50 | 50-100 | >100 | | | | 36.30 | 27.70 | 0.1400 |
| PCB | PPM | * | <0.5 | 0.5-1.0 | >1.0 | | | | 0.614 | 1.033 | 0.00003 |

NOTE: Gulf of Maine Tidal System Data from undated document from New England Division, U.S. Army Corps of Engineers. EPA Marine Water Quality Criteria taken from U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents", Federal Register, v. 50, no. 145, July 29, 1985. Values relate to "saltwater aquatic life" and represent a value not to be exceeded more than once, for a one hour period, every three years, on average. Massachusetts DEQE-DWPC classification from 314 CMR 9.00, regulations regarding the classification of dredge and fill material. ACOE testing requirements taken from an unpublished document, "Physical and Chemical Testing" dated 10 June, 1986, from New England Division, U.S. Army Corps of Engineers.

While the foregoing discussion points out the stated regulatory requirements regarding bulk sediment analysis, it should be considered as a list which is preceded by the words "including but not limited to". It is quite possible that additional testing might be required to identify compounds different than those in the bulk analysis, such as direct analysis of percent carbon, nitrogen, and phosphorous, chemical oxygen demand, or certain pesticides. It is, as a general rule, a good idea to take a look at the permit history of other dredging projects nearby to develop a rough idea of any additional testing that might be required, and, as always, to consult the permitting agencies.

C. Biological Analyses:

This is the third level of testing and involves assessing the potential impacts to individual organisms, populations and communities at both the dredge and disposal sites. Most of these tests involve field sampling or collection of organisms in the field and usually involve significant time and cost to the proponent. These tests are only required when the preceding testing indicates that there is a significant potential for adverse impact from the dredging or disposal of the material. As a general rule, if any of the bulk sediment analyses indicate that DEQE-DWPC Class III sediments are present, further testing will almost assuredly be required. If these analyses are required, a project has become significantly more complicated.

Elutriate Test: U.S. Army Engineer Waterways Experiment Station (1976) describes the elutriate test as a "simplified simulation of the dredging and disposal process wherein predetermined amounts of dredging site water and sediment are mixed together...and...analyzed for major dissolved chemical constituents". In essence, what it measures is the release of contaminants from the dredged material. If put into context (i.e. by calculating mixing zone values which provide a simple model of the current regime at the site) it is purported to produce important information to assess the availability of contaminants to an organism adjacent to the site.

Generally, the procedure is as follows. The elutriate is the supernatant (i.e. water left in the experimental container after the suspended sediment settles) resulting from a vigorous 30 minute shaking of one part bottom sediment from the dredge site with four parts water collected at the dredge site. This shaking is accompanied by aeration and is followed by a settling time of 1 hr., centrifugation, and filtration through 0.45um filters.

Not surprisingly, there are concerns about the efficacy of elutriate testing regarding how adequately it simulates the conditions at the dredge site, such as dissolved oxygen concentrations, and whether it simulates remobilization of all contaminants equally. Modifications and revisions to the test have been proposed (Brannon et al. 1976, Palermo 1986a, Palermo 1986b) but none of these new protocols have been officially incorporated into the regulatory framework.

E.P. Toxicity Test: Another chemical/biological test that has been required when upland disposal is proposed is the E.P. (extraction procedure) toxicity test, "designed to identify wastes likely to leach hazardous concentrations of particular toxic constituents into the groundwater" (Federal Register, May 19, 1980). The test, attempting to simulate the chemical processes which would be expected at a sanitary landfill, involves mixing the material with an acidic leaching medium (acetic acid, pH = 5) for a period of 24 hours. If the contaminant concentration exceeds an attenuation factor of 100 (i.e. the attenuation of toxicant concentration expected to occur between the point where the leachate is introduced to the system and the point of human or environmental exposure), the material is assumed to possess a high potential for contaminating groundwater.

A more rigorous replacement for the E.P. Toxicity Test has been proposed (Federal Register, June 13, 1986). The Toxicity Characteristic Leaching Procedure (TCLP) is similar to the E.P. Toxicity Test except that it involves a more vigorous extraction step and includes the analysis of 38 additional priority pollutants.

Recent DEQE-DWPC guidelines state that this test will no longer be required for upland disposal of dredged material which is subject to their policy guidelines (see Fig. 3.2).

Bioassay: A bioassay measures the mortality rate of aquatic organisms exposed to dredged material. The current standard procedure, called a "solid phase bioassay", involves subjecting selected organisms to dredged material for a period of 96 hours to ten days and beyond under controlled conditions. Survival of the test organisms is the criterion being measured and compared with the results of concurrent testing of a reference and a control site. This procedure is usually required for projects involving ocean disposal, and is most often the protocol as described by EPA and COE (1977) as modified by selected procedures from the NY District COE (1982) and the NED (1985). Three different types of organisms are usually tested and the results subjected to a battery of statistical tests. When results of the bioassay reveal that the difference in survival rate of the test organisms between the dredge and reference site does not exceed 10%, it is very likely that the material will be considered suitable for ocean disposal. Where the difference exceeds 10%, the material is more closely scrutinized. The 10% guideline is not a pass/fail threshold, but is considered as another piece of information on which to base the ultimate decision regarding the suitability of the material for ocean disposal.

Without going into a detailed critique, the procedure is not without those who find it lacking in a number of areas. White and Champ (1982) suggest that the potential for significant error is great and that differences in the age of test organisms can affect the results by as much as five orders of magnitude, with the sex of the test organism, genotypic differences in source test organism populations, exposure time, and a host

of other factors being lesser, though significant, sources of error. There has been some discussion of the utilization of different types of bioassays, such as population stress bioassays, which are comparatively immune from the kinds of sources of error cited above, but these are significantly more expensive than an already very expensive procedure, and are still being developed by academic and agency researchers. Until such time that some new procedure becomes available, conditions under which bioassays are performed must be carefully scrutinized and potential sources of error controlled as much as possible.

Bioaccumulation Testing: The federal Ocean Disposal regulations require that the potential for bioaccumulation (the accumulation of contaminants in the tissues of animals and plants) of contaminants be examined in the technical assessment of permit applications. In other words, the task is to determine whether an animal's (or plant's) exposure to the dredged material is likely to cause a significant elevation in the level of contaminants in its body compared with organisms exposed to sediments from a control or reference site, causing a potential public health risk. In order to accomplish this task, organisms are exposed to the material to be dredged under controlled conditions for a sufficient period of time, and the tissues of the organism examined for concentrations of toxicants. When compared with exposure to reference sediment, the differences in concentration levels provide an indication of the potential for bioaccumulation. Up to the third step of the process, this should look reasonably familiar...the bioassay discussed in the previous section...the third step is the central focus of bioaccumulation tests, to determine how much of a particular compound will be taken up by the organism given that the contaminant is known to be present at a concentration significantly higher than background levels. It should be noted in this regard that just because a compound (or suite of compounds for which one generic name is used, e.g. PCB) is present in the sediment does not necessarily mean that is in a form which can be easily taken up by the organisms living and feeding in and on the sediment. This is called the "bioavailability" of the contaminant.

The appropriate source for organisms is directly tied to the history of the project under review. The key factor involved is whether there is a "true historical precedent" for the project. If this precedent exists, then the bioaccumulation study can be limited to a body burden analysis of the organisms which are present at the disposal site, a so-called "field assessment". However, this can only take place under a very restrictive set of conditions. The project must be maintenance dredging, the quality of the sediment to be dredged cannot have deteriorated since the last dredging activity, and dredged material from that site must have been previously deposited at proposed disposal site or at a site of "similar sediment type and supporting a similar biological community" (EPA/COE 1977).

Given that these conditions can be rarely met, the usual bioaccumulation protocol involves the analysis of tissues from the organisms used in the bioassay. At the conclusion of the bioassay, the

appropriate tissues are removed and are usually analyzed for organohalogen compounds (e.g. PCB, DDT), mercury and its associated compounds, cadmium and its associated compounds, petroleum hydrocarbons, and "carcinogens, mutagens, and teratogens" if known or suspected. If the tissue concentrations are significantly (shown by statistical analysis) higher than the control or reference site, the implication is that a "potential for bioaccumulation" exists with respect to the dredged material.

The two questions arising from this that remain unclear are what does this statistically significant difference actually mean, and what are its regulatory implications. Given that, except in instances of gross change in body burden, the current state of knowledge regarding actual physiological effect of elevated contaminant levels may be insufficient to determine whether there will be any ecologically significant effects resulting from the projected increase in body burden, it is difficult to know when mitigation would provide adequate safeguards or whether the project should be prohibited outright. Most of the same criticisms regarding bioassays apply here as well in that the age, sex and source population of the test organisms, and exposure time may have a profound effect on the outcome of the analysis. Careful consideration of the potential sources of error may be useful in providing some measure of reliability of the test results.

Benthic Community Analysis: In some instances where major projects are involved, an analysis of the benthic (bottom dwelling) community may be required. This involves the collection of a large number of sediment samples, sieving them to remove the organisms, identifying and enumerating those organisms (usually to the species level), and statistically analyzing the results of the enumeration. This involves, because the analysis is statistical, a large number of samples as well as replicates of each sample, which may take up to tens of hours per sample to identify and enumerate. Needless to say, the cost of this analysis can run into, for a major project, many tens of thousands of dollars and up. Given the intensity of activity and cost involved, this should only be required when there is an unquestioned need for such information (which is sometimes not the case, leading to lots of badly done benthic analyses in project proposals). This type of analysis, unlike a more highly rigorous and more intensive benthic community analysis one might undertake in pursuit of more academic interests, is more qualitative, to get a "feeling for" which organisms are there and drawing a few general conclusions based on the current paradigm surrounding the dynamics of benthic communities. As long as the assumptions are stated and the conclusions are viewed in their proper context, this type of analysis may be considered appropriate within the regulatory framework.

This regimen of environmental testing with respect to dredging projects is not without its critics. While there is some merit in the uniform reporting of results (i.e. similar data being collected for all dredging projects, if what you are reporting has little ecological relevance, or has been shown to be subject to orders-of-magnitude error, some changes must be made. In response to some of the concerns expressed

regarding the existing protocols and procedures, the EPA is, in consultation with the ACOE, at the time of this writing, drafting revised environmental testing requirements. Until these are regulations are promulgated, good sampling design and adherence to the best laboratory and field procedures available will produce the best results obtainable from the existing protocols.

D. Sampling Design and Procedures

There are certain factors which are important in developing, or assessing the sufficiency of, a sampling design. The important questions are "where", "how", "how much", and "how many". Without some consideration of these questions, a great deal of wasted time and effort can result.

"Where" depends on how the resulting data will be analyzed. If a statistical analysis is required, random sampling locations may be necessary. Otherwise, locations chosen should be "representative". They should always be inside the dredging footprint (the perimeter of the area to be dredged) and within those confines, any location that is different from the others (e.g. intertidal mudflat, deep hole, or channel with a swift current) should be represented by a sample.

"How" is also an extremely important question. As an example, if the sample is being taken for heavy metals analysis, the sample should be isolated from contact with metal (no coffee cans, please), opting instead for plastic containers, acid-washed to remove any hydrocarbon or other contaminant residues. If organics are being analyzed, glass must be used instead of plastic. Most EPA, "Standard Methods" and other protocol sources have sections on proper sampling techniques that provide necessary test-specific details. The ultimate source, as with all testing requirements, should be the agency requiring the procedure. The most sophisticated analytical hardware available can do nothing to make up for inappropriate sampling techniques.

The "how many" question depends on the number of sub-samples or aliquots required for the various analyses anticipated. The rule of thumb is "too much is never enough". Like everything else, field sampling is an extremely expensive process and it is therefore better to take a little more than you need while you are there than have to go back out into the field after you discover that you are a few grams short or have lost a sample in transit. Having to return to the sampling area may also make the analysis much more difficult in that samples have been taken weeks or months apart, and in slightly different locations, may reflect entirely different environmental conditions.

"How many" is an extremely multifaceted question requiring that a delicate balance be struck between scientific accuracy/precision and cost per sample. Again, if statistical analyses are anticipated, Green (1979) suggests that the more samples you take, the more robust the statistical analysis will be to violations of the assumptions of the test being utilized and offers a number of suggestions as to how the appropriate number of samples can be derived.

Replicates must be taken as well to provide some estimate of the within-sample site variations. Again, "the more the merrier", but usually 3-5 will suffice.

Within an individual sample, a sub-sample from each horizon or layer should be taken and analyzed separately. If no horizons are evident, some sub-sampling of the core every 5-10 cm should be done. "Depth-averaging", a process which makes the entire core a composite sample, is rarely appropriate and should not be considered unless specifically called for by the agency requesting the information. Sampling should include the maximum depth of sediment to be dredged.

If no statistical analysis is anticipated, the number of samples should be sufficient to adequately characterize the site. Choose the most representative locations and make sure that no unique feature on the bottom within the footprint is left unsampled. Some preliminary sampling may be necessary to assure that all the features are included.

Striking a balance between the appropriate number of samples and the cost/sample can be an extremely difficult task, especially for the characterization of large and complex projects. This overview has, in large part, dealt with broad concepts regarding what is reasonable and appropriate in the environmental analysis of proposed dredging projects. It is, just to emphasize the point one more time, <u>always</u> best to talk to the regulatory agencies <u>before</u> you head out into the field to sample. While the agency may not tell you what you'd like to hear, at least you have saved yourself some time, potential aggravation, and money.

FUNDING PROGRAMS: PAYING FOR IT

Despite rising costs per cubic yard and severe cutbacks in funding programs, mud and sand continue to be transported into navigation channels and anchorages...cruel sea indeed. Given this essential truth, the question becomes (with apologies to the Bard) "to dredge or not to dredge". If the harbor has, over the years, become a haven for small boat sailors and all the deeper draft vessels have relocated to a different anchorage, the benefits of opening up such an embayment must be carefully weighed against the need for such an action, especially given its potential environmental and economic consequences. If, however, the frequency of groundings has increased in the past few years, the commercial and recreational traffic is having increasing difficulty getting in and out on some tides, and fisherman have been passing up the harbor and landing their catch in another port, the decision may be a little less difficult. Questions of public detriment versus benefit and the proper use of lands held in the public trust become central factors in the decisionmaking process. Every project, whether public or private, must meet certain criteria in this regard in the permitting process, and these questions must be addressed, especially when public funding is involved.

While funding from governmental agencies has decreased significantly in the past few years, the funding levels are not the only changes that have occurred. Where it was more common in the past for the Corps or some other agency to fund the complete project from planning to construction, now the cost of the project is shared by those deriving the most benefit from it. Both state and federal funding programs require this "cost sharing" and even a fair number of municipalities have followed this pattern with user cost sharing programs like the establishment of mooring and ramp fees. With this elemental change in funding programs has come more critical evaluation of plans for proposed dredging. Questions like "is this anchorage necessary" and "does the channel have to be that wide (or deep...or long)" are being heard in more and more cases. Now that the towns (and/or the state) are paying for part of the cost of projects, more questions are being raised...and more scopes of work are being revised to accommodate smaller planning and construction budgets. We are entering an era when interagency coordination and cooperation may be the only possible way to complete a dredging project. Things like sharing mobilization/demobilization costs and doing a number of small projects at the same time are occurring with greater frequency. It is only a matter of time before central coordination will be, especially for larger projects, an essential part of the process.

Visions of the future aside, it behooves the project proponent, especially the local harbormaster or town official, to be familiar with sources of funding, under what circumstances they may be

utilized, and who should be contacted for further information. As with the rest of the information contained herein, and as has been stated (and restated) in other chapters, it pays to have an understanding of the overall process...even if you have a consultant and/or engineer on retainer, no one is as concerned about your project as you are. As the project proponent (even the definition of 'proponent' indicates an active role...few successful projects have ever had a 'project benefactor'), staying on top of the process may be the only way that your project will be completed on time and within budget.

As a final caveat, much of the information regarding the funding of dredging projects seems to change on a weekly or monthly basis as they evolve and are acted upon by the winds of political change. You can really be certain of only three things; that the local interests will be bearing a greater and greater portion of the total costs of dredging projects, that funding will be increasingly more difficult to secure, and that, like the swallows to Capistrano, the mud will always return to the channel.

## FEDERAL PROGRAMS

Corps of Engineers: The federal agency synonymous with 'dredging' is the U.S. Army Corps of Engineers, whose federal navigation projects have allowed safe passage on waterways since the 1820's. The Corps has primary responsibility for these federal navigation projects in the maintenance of existing channels, anchorages, breakwaters, and jetties and the improvement dredging of new or expanded channels. Until a few years ago, the Corps owned one of the largest fleets of dredges and support vessels in the world and was involved in almost all dredging projects in the navigable waters of the United States.

However, recent Congressional action and ensuing changes in Corps policy have significantly changed the role of the Corps in the process. No longer the singular driving force, the fleet of dredges has dwindled to five or six and the projects require a local sponsor, someone to pay the local 'share' (as determined by the Corps) of the costs. While no longer a free ride to the town or city, the 'up-side' is that local sponsors will be provided with the opportunity to affect the outcome of the project...'if you pay, you have a say'. Although the details of how this will work are still evolving (because this is such a radical departure from what has been), it appears that all parties involved will most likely benefit from the changes.

While the details of the new process could fill volumes (but, suprisingly, does not...not much of this has not gone beyond what is detailed in the Water Resources Development Act of 1986 as it was recently approved by the Congress), what it basically boils down to is a series of questions related to need, uses, costs, and benefits. Before anything else, however, the question of 'project type' should be addressed. If the project involves maintenance dredging of an existing federal navigation

channel, the full cost of the project is borne by the Corps (at least as of this writing). In the future, it is distinctly possible that newly authorized federal navigation projects or predominantly recreational harbors may become subject to cost sharing when maintenance dredging is contemplated. For now, however, all costs directly related to maintenance dredging of a federal navigation project are provided by the Federal Government.

This does not include, however, costs associated with locally mandated alterations to the project as it was approved (or 'authorized') in Washington. If, for instance, the project authorization calls for offshore disposal, as the most cost-effective disposal alternative, but the Commonwealth or affected municipality wanted the material to be used to nourish the local public beach, the Corps would consider the change only if some other source of funding paid for the difference in cost to do the beach nourishment. While no state funding is available specifically for such a purpose, a remedy to this situation is currently being sought.

If the project under consideration is improvement dredging or other navigation improvements (new jetties, breakwaters, etc.), the 'cost-sharing meter' begins almost concurrently with the gleam in the eye of the project proponent as he or she begins to contemplate the possibility of such a project. The Corps preconstruction planning for small navigation projects involves conducting a two-phase study. The first phase, the "reconnaissance study" (RS), is typically completed in twelve months. In the preliminary stages of the RS, a determination is made as to whether there is a "federal interest" in the project proposed by the local community and whether an implementable solution (i.e. if the engineering is practical, whether environmental conditions at the site would preclude the project, etc.). This first decision is usually made within 60 days of the request for assistance. If the decision is to go forward, the Corps will complete the RS. As a final stage in the RS, the Corps would negotiate and execute a Study Cost Sharing Agreement with the local project sponsor to bear part of the cost of the second and final phase of the process, the Feasibility Study (FS).

In order to move forward, one of the most important criteria is that the <u>Benefit</u> <u>to</u> <u>Cost</u> <u>Ratio</u> (BCR) must be greater than 1 (i.e. that the benefits of the project outweigh the costs) <u>and</u> that the project will stand on the commercial benefits alone. This split in source of benefits is extremely important to the ultimate decision to fund the project. If the harbor under study happens to be predominantly recreational (i.e. not much in the way of commercial fishing boats or shoreside support services), the chances for Corps funding are slim.

The Feasibility Study (FS) involves developing preliminary plans for the project, a more complete cost-benefit analysis, and working out the details of the cost-sharing contract documents. This is the first phase to be subject to cost-sharing. FS costs are equally split between the

Corps and the local sponsor. Of the local share, 50% of this 50% must be up-front cash or any contract service (e.g. pay local contractors for providing detailed bathymetry of the site, or other such contract service). The remaining 50% of the local share can be paid in cash or through in-kind services. These services can be anything from providing local review time, time for relevant local agencies to attend meetings, to providing local information...time and materials all negotiable. The "arrangement" worked out between the local sponsor and the Corps can be very flexible, and each is specific to the project at hand and the talents and expertise available to the sponsor. Careful negotiation at this phase can save a sponsor a significant amount of "cash money" through the taking full advantage of this flexibility.

The FS contains a comprehensive and relatively complex suite of analyses regarding project options, potential economic and environmental impacts, and project conditions. This document is, for all intents and purposes, the sole justification for the project. Authorization rises and falls on the results of these analyses.

The upshot of the FS analyses (and final BCR calculation) may be that the project may require certain modifications in order for it to be authorized. As an example, if the channel was supposed to be dredged to 8 feet (that determined appropriate to allow all user vessels adequate depth), but the FS revealed that the commercial vessels required only 6 feet at low water, the project would be scaled back to reflect this finding. However, should the local sponsor be willing to bear the costs of dredging the additional 2 feet, the Corps would most likely be willing to reconsider their decision to modify the project.

The determination of the cost-share for the construction phase is a bit complicated, the local share depending on the depth of the proposed channel, and percent recreational benefits considered in the BCR calculation. The breakdown for commercial harbors and channels is as follows:

| Depth of Channel | Federal | Local | Cash Up-Front |
|---|---|---|---|
| < 20 ft. | 80-90% | 10-20% | 10% |
| 20 - 45 ft. | 65-75% | 25-35% | 25% |
| > 45 ft. | 40-50% | 50-60% | 50% |

The second part of the calculation is the benefits correction factor, best explained by an example. Suppose the BC analysis revealed that, for a particular channel < 20 feet with an initial split of 80/20, 90% of the benefits are commercial and 10% recreational. From the initial split, the 10% recreational benefits would be split in half, with one half subtracted from the federal share and the other half added to the local share, thereby resulting in a final corrected split of 75% federal and 25% local. Expressed in a formula:

$$TPC(\%) = [FS - (RB/2)] + [NFS + (RB/2)] = 100\%$$

where: TPC - Total Project Cost (= 100%)
FS - Federal Share
RB - Recreational Benefits
NFS - Non-Federal Share

Not exactly straightforward but not too difficult once you get the hang of it. Remember that circumstance, creativity, and/or the whims of congress and the implementing agencies, may alter this at any time, but it is difficult to believe that it will stray too far from the general format currently in use. But, as mentioned before, two of the things that you can count on are that cost-sharing is here to stay, and to look for the local share to be the one that will see future increases.

It is important to be frugal in your offers to pay cash to anyone at any time in the process...after all, the cash you offer is money that was paid to a government agency at one time or another by some sort of taxpayer. Be creative...in the case of up-front money, look for contract services which you, as local sponsor, can provide at a reduced cost because, say, a boat owner in the harbor happens to own a company which has side-scan sonar equipment. Investigate all the possibilities available to you. In the case of the balance of the local share, make sure all your in-kind services are included in the calculations. Ask the Corps for copies of previously negotiated agreements from other projects to see what types of in-kind services were included. Carefully evaluate who will be involved and how much time will be spent on the project. Has the trip to Boston to review CZM federal consistency requirements been included? Has the time on the phone running down the permits and licenses been included in the calculations? Be realistic...but make sure you have explored all possible options.

Preconstruction planning is followed by a review of the resulting report and recommendation by the Corps in Washington, D.C.. Should they agree with the recommendations, information is sent on to the Assistant Secretary of the Army for Civil Works, where it undergoes additional review, leading, hopefully, to authorization. Once authorized, plans and specifications would be developed for the project and bids solicited.

In terms of time involved, from the initial appraisal to the bucket breaking the surface of the water could be anywhere from 4-8 years (yes, years) with the low end figure assuming vast improvements in communication between the agencies with an interest in the project. The process is definitely not fast by any stretch of the imagination, but when you are dealing with at least hundreds of thousands, up to millions of dollars per project, no one can be faulted for carefully weighing their options.

Congressional Action: This particular option is included with great reluctance in that it is, when all is said and done, not a very good idea. Even if your project gets past being referred back to the Corps, you (and your congressional allies) will still have to defend against charges of "pork barrel" and explain why you didn't go through the usual programs and why your project is so unique vis-a-vis the national interest. Except in the rarest circumstances, chances for success are very slim indeed.

## STATE PROGRAMS

Department of Environmental Management- Waterways Division: Not to be confused with DEQE-Waterways (which is the regulatory agency responsible for issuing so-called "Chapter 91" licenses), DEM-Waterways, Rivers and Harbors Program is one of the two largest sources for funding of dredging projects in the Commonwealth (the other, of course, is the Corps). Under Chapter 723 of the Acts of 1983, the program was established in its present form for the purposes of "general renovations and improvements to the various inland and coastal waterways of the Commonwealth". Funding projects which typically range from $50,000 to $500,000, the program requires that the project serve a water-dependent use, be of great urgency or need, be technically feasible, comply with the letter and spirit of the environmental laws, and have broad community commitment. This last criterion is manifested by the community providing 25% of the design and construction costs for the project. For a more complete list of criteria regarding community commitment and more, see Figure 7.1.

The request for funding entails the submission of an application packet which includes: 1) a "summary petition", the formal request for funding consideration; 2) an executive summary, which describes the project and estimated costs, documents the urgency and need, details the public benefits accrued from the project, discusses the potential environmental impacts and appropriate mitigation, and describes how the project is compatible with other federal, state, and local plans or projects; 3) a locus map; 4) a schematic plan; 5) preliminary cost estimates; 6) details of quantity and quality of material to be dredged and suggested method of disposal.

There is typically one round of funding each year (around April/May) whenever money is available or pending. The petitions are reviewed by an interagency board and evaluated based on the program criteria.

For questions regarding the program or the applications process, contact DEM-Division of Waterways, 100 Cambridge Street, Boston, MA 02202, (617) 727-8893.

## FIGURE 7.1 - CRITERIA FOR EVALUATING PETITIONS (from DEM-Waterways Memorandum dated 1 March, 1985)

Petitions shall be prioritized based upon the urgency of or need for the project, the water-dependency of the proposed use, the public purpose served by the project, the technical feasibility and environmental acceptability of the proposed project, and the overall support for the project.

(1) Urgency of and Need for the Project

This shall be based on the following categories:

(a) The degree of threat to public safety and public health from the existing condition as a result of:
  - (i) flood and storm damages
    - impending structural breaks or collapse
    - potential numbers of persons affected
    - potential damages to property
  - (ii) sedimentation and erosion
    - pollution caused and its effects on public health and natural resources
    - lost productivity of agricultural, mineral or other resources
  - (iii) hazards to navigation
    - potential numbers, sizes of vessels restricted from using the established course
    - potential vessel damages from avoiding and/or coming in contact with the hazard
    - the degree to which safe turning and berthing is jeopardized
    - no clear line of sight for safe navigation
    - diminished ability to handle vessels safely due to interference from tidal action/currents
    - lack of access from all areas to navigational channels

(b) The need for the project including:
  - (i) unmet demand for recreational facilities or dredging in terms of potential numbers of users and expected frequency of use
  - (ii) inadequate compliance with the public rights of fishing, fowling, and navigation
  - (iii) lack of high quality public access (physical/visual) and poor availability of existing access to the public (little or no encouragement to use the public access)
  - (iv) resource degradation and depletion
  - (v) unmet demand for commercial facilities or dredging in terms of potential vessels and commodities to be served and the expected impact on local and state economies
  - (vi) inadequate or dilapidated existing facilities for either commercial or recreational use

(c) Maintenance dredging and repair and renovation of existing structures will be preferred to improvement dredging or new structures

Figure 7.1 (cont.)

(2) Water-Dependency of the Proposed Use

Priority will be assigned in the following order:

(a) water-dependent commercial uses (maritime, fishing)
(b) water-dependent recreational uses (boating, fishing, swimming)
(c) water-related commercial and recreational uses with access to waterways use
(d) water-related uses without access to waterways use
(e) non-water-related uses

(3) The Public Purpose Served by the Project

This shall be determined through an analysis of the benefits and costs to the public that are to be derived from the project. The greater the benefits to the public, the higher the priority for project selection. The analysis will include consideration of the following:

- the constituency served by the project in terms of capacity and expected numbers of users of facilities or beneficiaries of the project
- the access of the project to all the public
- the economic impact of the proposed project on the marine commerce, fishing, recreational and/or tourist and other water-dependent industries of the community
- the secondary effects of the proposed project on the local and state economies
- the improvement to public safety and health resulting from the proposed project
- the identification of estimated project costs borne by the public for both construction and maintenance
- the opportunity costs involved in a no-action alternative
- the costs of mitigative measures to ensure environmental integrity

(4) Engineering Feasibility

Because only a schematic plan is required in petitioning for waterways improvements, only the most basic criteria must be met. Generally, petitions will be evaluated by applying the following criteria to the extent possible:

- the schematic design including the methods, materials, and equipment proposed must effectively address the problem identified without creating additional problems
- the basic structural designs must reflect the application of sound engineering principles
- the design must be compatible with abutting structures in general design, size, function, and materials

FIGURE 7.1 (cont.)

- innovative methods and materials may be acceptable with documentation of their potential effectiveness in addressing the problem identified
- the infeasibility or ineffectiveness of non-structural alternatives must be demonstrated where structural solutions are proposed
- the estimated costs must be reasonable and realistic in addressing the problem at hand
- if dredging is proposed, realistic disposal options must be identified

The cost effectiveness of the project in addressing the identified problem and serving the greatest public purpose will be considered in determining priorities.

The frequency and expense of maintenance will be considered in determining priorities. Generally, those projects with an unrealistic chance for proper maintenance will be ranked lower than those for which maintenance is assured and minimal.

(5) Environmental Acceptability

The proposed project's effects on significant areas of concern will be considered with projects having the least impacts receiving the highest priority. Project effects on the following environmental areas will be considered: open space and recreation; historical; archeological; fisheries and wildlife; vegetation and trees; other biological systems; inland wetlands or beaches; flood hazard areas; chemicals, hazardous or high risk substances; geologically unstable areas; prime agricultural and mineral resources; energy use; noise; traffic; solid waste; aesthetics; wind and shadow; growth impacts; community housing and the built environment; sensitive receptors such as hospitals, schools and residential areas.

Possible costs and benefits of mitigative measures and cumulative impacts will be considered in determining environmental acceptability. Short-term effects, if mitigated, will be of less concern than potential long-term effects.

(6) Support for the Project

The following types of support will be considered in evaluating projects:

(a) Financial Support: The local government proponent must be committed to cover 25% of the costs of dredging projects and 50% of the cost of any other projects. Any lesser commitment may deem a project ineligible for funding. The local government proponent must also be committed to fully funding and administering project operation and maintenance. Any lesser commitment may deem the project ineligible for funding.

Figure 7.1 (cont.)

(b) Interagency Support: To be eligible for funding, a community must be in compliance with Affirmative Action Regulations 310 CMR 50.00 and Executive Office of Communities and Development Executive Order 215.
Duplication or overlap with other state programs shall be avoided. Where other state programs more adequately address a specific problem, projects proposed to address that problem will be given a lower priority for funding under the Division of Waterways program.
The proposed project must comply and be consistent with all existing local and state plans and policies. The greater the degree of consistency, the higher the priority. In the same fashion, the more the project complements ongoing local and state efforts, the higher the priority. The relationship of the project to such policies as the Governor's Office of Economic Development priority areas, Office of Coastal Zone Management designated port areas and special assistance development areas, and the Executive Office of Communities and Development Commercial Area Revitalization Districts will be considered favorably.

(c) Community-Wide Support: Community-wide support will be measured by the following factors:

- the documented support of the project by local economic development, environmental, and public interest groups
- the documented commitment to the project by local elected officials and legislators
- the documented support for the project from abutting property owners and users

Documentation for support may be in the form of a letter submitted with the application, testimony at a Rivers and Harbors hearing, or other verbal or written support resulting from site visits or ongoing correspondence.
The broader the range of interests supporting the project and the deeper the support, the higher the priority for implementing the project.

Executive Office of Communities and Development: EOCD has a number of programs which may fund dredging (or aspects thereof) as an incidental activity related to coastal economic development. The operative word here is "incidental"...they are not in the business of funding dredging projects nor will most dredging projects meet the restrictive conditions, especially the leverage requirements, of the various programs. However, EOCD is willing to consider funding such an activity if it is compatible with the mission of the Secretariat.

Feasibility Study Grants: This program funds studies to assess the feasibility of economic development projects. Grants are awarded for analyses in the areas of engineering, marketing, impact, financing, and organization. Grants are made to towns with less than 50,000 population and are limited to $30,000. In terms of funding for dredging-related projects, this program has funded a study in the Town of Sandwich to examine the use of publicly owned land on the harbor, which included an examination of the feasibility of dredging. For further information regarding eligibility requirements and applications procedures, contact: Feasibility Study Grants Program Director, EOCD, 100 Cambridge Street, Boston, MA 02202, (617) 727-3197.

Community Development Action Grants: This program is designed to promote privately-funded development activity, investment, create or retain jobs, and revitalize distressed areas by financing infrastructure improvements on sites where projects cannot proceed due to inadequacies in the public infrastructure system. Local project grant requests cannot exceed $1,000,000 for any funding round. Given the stated purpose of this funding program, it is not surprising that private sector commitment is required. For every $1.00 of project cost, there is a leverage requirement of $2.50 in private investment directly related to the improvement in the public facility. There are a broad range of private investments which may be acceptable in meeting this requirement. For detailed information regarding eligibility requirements and applications procedures, contact: CDAG Coordinator, EOCD, 100 Cambridge Street, Boston, MA 02202, (617) 727-3197.

Massachusetts Small Cities Program: The purpose of this program is to make available funds for a wide range of community-based economic development projects ranging from economic development and housing rehabilitation to infrastructural improvements. One of the potentially fundable projects under the provisions of the "General Fund" aspect of the program is dredging when it is associated with providing public services and improvements. Like all EOCD funds, dredging must be associated with private capital investment leading to the revitalization of a community's waterfront areas. For information on specific requirements and applications procedures, contact: MSCP General Fund Program Manager, EOCD, 100 Cambridge Street, Boston, MA 02202, (617) 727-0494.

Just to emphasize the point, none of these EOCD funding programs are necessarily in business to assist local communities with dredging projects. They are there to assist communities with economic development...if dredging happens to meet the criteria, so much the better. EOCD has been included here because in the past, dredging and dredging-related projects have been funded by EOCD monies. More often than not, you will be referred to DEM-Waterways...but it doesn't hurt to ask.

Legislative Action: As is also the case with Congressional action, this is a method of last resort. The Legislature finds it most irregular, though not unheard of, to act on a bill when there is an administrative procedure in place to do the job (in this case administered by DEM-Waterways). The only time that is may be appropriate is when the DEM funding programs are out of money and you can clearly show the necessity of the project. Otherwise, normal channels produce better results.

## LOCAL FUNDING

What should be readily apparent from the foregoing discussion is that everyone who has funding available has made it clear that a portion of the total project cost must be supplied by the local sponsor, those benefiting most from the activity. This is not really such a bad idea considering that the folks from Fargo, North Dakota, or North Adams, Massachusetts, may have a bit of difficulty coming to terms with the benefit they derive from a dredging project in Chatham or Newburyport. Even when you place your article in the warrant and defend it on town meeting floor, it may be difficult to sell to the fellow who doesn't own a boat, can't stomach fish, or would never consider taking a long walk on the beach. The point is that if you buy the concept of cost-sharing, why not extend it to the local level.

Under a town's "Home Rule" powers, it can adopt by-laws or ordinances which assess fees to help defray the cost of constructing or maintaining public amenities or providing services to the community. Many towns have opted for adopting mooring, ramp usage, or other fees directed at the primary users of the harbor. While the funds generated cannot, without special legislation, be dedicated to support a particular activity (it goes into the General Fund), a gentle reminder of the source of these funds to the Finance Committee and on town meeting floor can go a long way to sell an article dealing with dredging the harbor (especially if this possibility was mentioned when the fees were adopted).

In general, it pays to talk to other towns to see what they are doing and how they are doing it. Some towns have been remarkably successful ...others have failed miserably. Much can be learned from both.

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As to availability, many of these works (and others related but not referenced in this review) are on file at Massachusetts Coastal Zone Management, 100 Cambridge Street, Boston, MA 02202. Those papers from the scientific literature not available for consultation at MCZM can be obtained from many academic libraries. Even if the library does not hold that particular journal, copies can be optained through inter-library loan at a nominal copying cost. Government publications are available from two major sources, the National Technical Information Service (NTIS) in Virginia, and directly from the agency producing the document. For instance, the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi, can provide copies of their publications upon request. Should you require any of these publications, MCZM can assist you in your search.

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## DREDGING
### Definition

Dredging is the mechanical process of removing, excavating, or mining of sands, silts, muds or other sediments from land under water. (Removal, as opposed to dredging, is generally used to describe removal of material from areas above mean high water, such as dunes).

Note that for land under the ocean, the Regulations make the distinction between "improvement" dredging and "maintenance" dredging.

Also note that dredging is subject to regulation by the Department of Environmental Quality Engineering (DEQE) through its Divisions of Waterways (Ch. 91, MGL) and Water Pollution Control (Ch. 21, MGL), the U.S. Army Corp of Engineers (Waltham) and the U.S. Environmental Protection Agency (Boston).

Illustration 30: Dredge and scow

APPENDIX A - EXCERPT FROM "A GUIDE TO THE COASTAL WETLANDS REGULATIONS" DEQE/MCZM (1978)

## Activity Acceptability Table

This table indicates in which Resource Areas dredging is or is not likely to be able to be conditioned to meet the performance standards set forth in the Regulations.

| Resource Area | Acceptability |
|---|---|
| Land Under the Ocean Section 25 | likely to be conditioned. |
| Designated Port Areas Section 26 | likely to be conditioned. |
| Coastal Beaches Section 27 | may be conditioned in limited situations. |
| Coastal Dunes Section 28 | unlikely to be proposed — see Removal. |
| Barrier Beaches Section 29 | may be conditioned in limited situations. |
| Coastal Banks Section 30 | unlikely to be proposed — see Removal. |
| Rocky Intertidal Shores Section 31 | likely to be conditioned. |
| Salt Marshes Section 32 | not likely to be acceptable: Sec. 32(3) states that no portion of a Salt Marsh may be destroyed. |
| Land Under Salt Ponds Section 33 | not likely to be acceptable: any dredging in a salt pond will have an adverse impact on marine fisheries habitat. Note exception in Sec. 33(4) |
| Land Containing Shellfish Section 34 | not likely to be acceptable in DMF mapped shellfish areas: dredging adversely effects such land and marine fisheries which is not permitted under 34(4). Note exception to this under 34(5). Likely to be conditioned in non-DMF mapped shellfish areas. |
| Fish Runs Section 35 | likely to be conditioned. |

# DREDGING

## Section 25 Land Under the Ocean

### A. Improvement Dredging

| Interest to be Protected | Adverse Effects to Interest | Conditions Required to Meet Performance Standards. | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Storm damage prevention and flood control | ■ The deepening of the near-shore bottom may result in an increase in the height of waves impacting the shore. | *1. Best available measures to meet Sec. 25(3)(a).*<br>■ Minimize depth of dredging — no more than necessary to accommodate the draft of the deepest draft vessel expected to use the harbor, at mean low water.<br>■ Minimize channel width — no more than necessary to accommodate the beam of the widest vessel to use the harbor.<br>■ Whenever possible, channel axis should not be parallel to the direction of major storm waves. | ■ Deepest draft vessel expected<br>■ Mean low water elevation<br>■ Existing depth in proposed channel<br>■ Largest beam expected<br>■ Direction of major storm waves. |
| | ■ A channel may interrupt the sediment transport process, thereby affecting the natural replenishment of beaches. | *2. Best available measures to meet Sec. 25(3)(b):*<br>■ Where the dredging is flanked by coastal beaches or barrier beach, a sand by pass system must be developed so that the net littoral drift is not diminished to the downdrift beach. This may be done by periodic dredging of the channel and deposition of compatible dredged materials on the downdrift beaches or downdrift beach replenishment. If sediments in the channel become polluted or incompatible with the downdrift beach sediments, beach nourishment from the dredged area will not be allowed. | ■ Description of the shoreline adjacent to and potentially impacted by the dredging — structures, bank or beach conditions, etc.<br>■ Calculation of existing wave energy impacting area described above. Calculation of energy impacts after the proposed dredging.<br>■ If energy impact is different, show engineering solutions to compensate.<br>■ Identification of legally responsible party for maintaining by-pass system or periodic beach nourishment.<br>■ A timetable for periodic beach nourishment or replenishment dredging.<br>■ Potential pollutants within dredged area *<br>■ Description of grain size of dredged sediments and downdrift beach area<br>■ A detailed plan indicating the exact area to be dredged, the amount of material to be [illegible] and the prop[illegible] |

*See Division of Water Pollution Control Regulations

| Interest to be Protected | Adverse Effects to Interest | Conditions Required to Meet Performance Standards | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Protection of marine fisheries | ■ Dredging may create an area of stagnation resulting in a deterioration of water quality. | *1. Best available measures to meet Sec. 25(3)(c):*<br>■ A condition which minimizes depth (as above) will also help meet this standard.<br>■ Dredge the channel so that all portions of it will be adequately flushed by the tides. | ■ Bathymetry of proposed project |
| | ■ Dredging may reduce marine productivity by destroying bottom habitat, by increasing turbidity, by stirring up pollutants, and by causing siltation which may bury bottom animals adjacent to the channel. These may, in turn, allow organisms to ingest and accumulate the stirred up pollutants and the siltation may destroy habitats or food source areas. | *2. Best available measures to meet Sec. 25(3)(d):*<br>■ Dredging should be done between October 1 and March 15.<br>■ Hydraulic dredging shall be employed where physically possible.<br>■ Where hydraulic dredging is not physically possible, the largest practical dredging bucket or clamshell shall be used.<br>■ Siltation curtains shall be used to completely enclose the dredged sediment plume, where conditions permit.<br>■ Dredging should avoid eel grass beds to the extent possible. | ■ Size and location of plume based on type of equipment to be used, substrate conditions, and hydrographic conditions (depth and currents). |

# DREDGING
## Section 26 Designated Port Areas

| Interest to be Protected | Adverse Effects to Interest | Conditions Required to Meet Performance Standards | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Protection of marine fisheries | | *1. Best available measures to meet Sec. 26(3):* | |
| | ■ Dredging may adversely affect water circulation by creating areas of stagnation. | ■ Dredge channel and port area so that all portions of them will be adequately flushed by the tides. | ■ Existing and proposed hydrography of designated port area. |
| | ■ Dredging may adversely affect water quality by changing dissolved oxygen, temperature, turbidity, or by stirring up pollutants in the bottom sediments.* | ■ Complete the dredging operation as quickly as possible by using the most efficient and practical equipment. | ■ Chemical, physical, and biological analysis of bottom sediments.** |
| | | ■ Where possible, schedule dredging so as not to conflict with fisheries use. | ■ Identify fisheries in the proposed dredged area, particularly anadromous/catadromous fish runs. |
| Storm damage prevention and flood control. | | *1. Best practical measures to meet Sec. 26(4).* | |
| | ■ Extensive dredging of a port area may increase wave height, which may increase their potential destructive energy. | ■ Minimize the amount of dredging | ■ A detailed plan indicating the exact area to be dredged, the amount of material to be dredged, and the proposed dredged material disposal site. |
| | | ■ Whenever possible, channel axis should not be parallel to direction of major storm waves. | ■ Scientific and/or engineering studies to show the storm surge before and after dredging |
| | | | ■ Direction of major storm waves |

*A high concentration of certain pollutants in the bottom sediments, such as PCB's or heavy metals, may preclude the possibility of dredging under the regulations of the Division of Water Pollution Control (DWPC).

**Bottom sediment analysis and evaluation of dredging should be coordinated with the DWPC.

# DREDGING
## Section 27 Coastal Beaches and Section 29 Barrier Beaches

| Interest to be Protected | Adverse Effects to Interest | Conditions Required to Meet Performance Standards | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Storm damage prevention and flood control | ■ Dredging a beach (or tidal flat) may increase the wave energy reaching the shore, thereby changing the volume and form of adjacent beaches and increasing the erosion potential. | *1. Measures to meet performance standards of "no adverse effect" — Sec. 27(3)* | |
| | | ■ On most beaches, there are no measures to reduce the adverse effects to the required level. Therefore, all beach dredging should be denied except in the following two circumstances: | ■ Documentation of the existence of a tidal inlet prior to the filing of a Notice of Intent for the proposed dredging. |
| | | ■ 1. dredging through a shoal within existing jettied or natural tidal inlets. | ■ Description of current conditions, extent of proposed dredging, and location of dredge spoil disposal |
| | | ■ 2. dredging in a tidal flat in a harbor provided that the applicant can demonstrate that there will be no increase in the erosion of adjacent coastal beaches, coastal dunes, or salt marshes | |
| Protection of marine fisheries | ■ Dredging as permitted under Sec. 27(3) — see above — may cause changes in water quality, particularly the level of turbidity | *1. Best available measures to minimize adverse effects — Sec. 27(6)* | |
| | ■ As sediments settle out on adjacent tidal flats, the distribution of sediment grain size may change. | ■ Dredging should be done between October 1 and March 15. | ■ A detailed plan indicating the exact area to be dredged, the amount of material to be dredged, and the proposed dredged material disposal site. |
| | ■ There may be pollutants in bottom sediments which will be disturbed and transported to adjacent areas. | ■ Hydraulic dredging shall be employed where physically possible. | |
| | | ■ Where hydraulic dredging is not physically possible, the largest practical dredging bucket or clamshell shall be used | |

# DREDGING
## Section 34 Land Containing Shellfish

| Interest to be Protected | Adverse Impacts to Interest | Conditions Required to Minimize Adverse Impacts | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Protection of land containing shellfish and marine fisheries | ▪ Dredging in any portion of any Resource Area which contains shellfish alters the relief and elevation of the area | *I. Measures to meet performance standard of "no adverse effect" Sec. 34(4)* | |
| | | *A. In a DMF mapped shellfish bed* (34(3)(a)) there are no measures which will make dredging meet the "no adverse effect" standard, except dredging which will immediately and purposefully be filled such as for laying a pipe, which is permitted under Sec. 34(5)<br>▪ In order for a project to be permitted under Sec. 34(5) in a DMF mapped area, the following conditions must be met:<br>▪ shellfish in the area to be dredged must be relocated to a suitable location approved by DMF.<br>▪ substrate identical in sediment composition, sediment grain size, and density to that removed must be used to fill the dredged area.<br>▪ relief and elevation must be returned to pre-existing conditions<br>▪ siltation curtains designed and employed so as to preclude the transport of sediment from the dredging site onto other areas of the shellfish bed shall be employed where physical conditions permit.<br>▪ if turbidity will impact other shellfish bed no dredging shall be allowed during the larval setting stage. | ▪ Existing substrate condition in the area to be dredged including sediment composition, sediment grain size, and sediment density.<br>▪ Existing relief and elevation<br>▪ Proposed location of relocated shellfish and evidence of DMF and local shellfish constable approval. |
| | | *B. In a non-DMF mapped shellfish area* (34(3)(b)), dredging may be permitted under the following conditions:<br>▪ that the shellfish in the area to be dredged be relocated in a manner and to a location suitable and approved by DMF and the shellfish constable.<br>▪ siltation curtains designed and employed so as to preclude the transport of sediment from the dredging site onto other areas of the shellfish bed shall be employed where physical conditions permit.<br>▪ if turbidity will impact other shellfish beds, no dredging shall be allowed during the larval setting stage | ▪ Existing substrate condition in the area to be dredged including sediment composition, sediment grain size, and sediment density<br>▪ Existing relief and elevation<br>▪ Proposed location of relocated shellfish and evidence of DMF and local shellfish constable approval.<br>▪ A detailed plan indicating the exact area to be dredged, the amount of material to be dredged, and the proposed [illegible] dredged material [illegible] |

| Interest to be Protected | Adverse Effects to Interest | Conditions to Minimize Adverse Effects | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Storm damage prevention and flood control | ■ Dredging rocky intertidal shores will reduce the volume and change the form of the shore. This may effect its ability to dissipate wave energy and to provide a buffer to inland areas. | *1. Best practical measures to minimize adverse effects — Sec. 31(3)*<br>■ The surface of the side slopes after dredging should have the same (or as close as possible) roughness and be of the same (or as close as possible) materials as the dredged area was prior to dredging. | ■ Qualitative description of the roughness and materials in the area to be dredged before and after dredging.<br>■ A detailed plan indicating the exact area to be dredged, the amount of material to be dredged, and the proposed dredged material disposal site. |
| Protection of marine fisheries | ■ Dredging of rocky intertidal shores is not likely to have an adverse effect on water circulation and water quality. | *1. Best available measures to meet Sec. 31(4)*<br>■ None required for dredging | |

## DREDGING
### Section 35 Fish Runs

| Interest to be Protected | Adverse Impacts to Interest | Conditions Required to Minimize the Adverse Impact | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Protection of marine fisheries | | *1. Measures to meet performance standard of "no adverse effect" — Sec. 35(3)* | |
| | ■ Dredging in a fish run creates a turbidity plume which may impede the migration of fish. | ■ No dredging shall be permitted during a fish migration. | ■ Identification of anadromous or catadromous fish which use the fish run and their migration times |
| | ■ The sediment particles created by dredging may settle out on and cover spawning and nursery habitats. | ■ Siltation curtains which completely enclose the turbidity plume shall be used when the sediment would otherwise settle out on spawning or nursery habitats, where physical conditions permit. | ■ Scientific studies which clearly delineate spawning and nursery habitats. |
| | ■ Dredging changes the cross-section of a channel, thereby altering the rate of water flow through the channel. | ■ Dredging shall not change the rate of water flow so as to impede the migration of fish. | ■ Rate of flow during migration season before and after proposed dredging. |
| | ■ Dredging may destroy spawning and nursery habitats. | | ■ A detailed plan indicating the exact amount of material to be dredged, and the proposed dredged material disposal site |

## Definition

Dredged Material Disposal is the process of discharging, depositing, dumping or utilizing the by-products of a dredging operation.

Dredged material disposal may occur on land, or if clean, in several of the coastal Resource Areas. Dredged material disposal commonly occurs at designated dump sites on land under the ocean, most of which are seaward of the municipal boundaries.

The volume, physical and chemical characteristics of the dredged materials (commonly called dredge "spoils"), the location of the dredging project, and federal and state requirements will dictate the methods of transport and ultimate location of the dredge material disposal site.

Common shore-based dredged material disposal sites and uses for clean material include, but are not limited to, dumping at an approved sanitary landfill, utilization as "fill" material for construction purposes, and deposition of clean dredged material onto coastal environments to replenish eroded sediments.

Off-shore dredged material disposal sites and uses include, but are not limited to, ocean dumping in approved areas, and deposition of dredged material in off-shore zones to replenish eroded or drifted materials.

If dredged materials are highly contaminated with toxic substances and would have little or no commercial value, then disposal in an approved dumping location may be the only alternative.

The ocean disposal of dredged materials must conform to the Waterways (MGL. Ch. 91) Regulations, the Massachusetts Ocean Sanctuaries Act and the Division of Water Pollution Control discharge permit criteria, as well as regulations promulgated by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency. The Divisions of Water Pollution Control and Waterways (DEQE), and the Army Corps should always be consulted in addition to the conservation commission, especially when toxic materials may be present in the dredged materials.

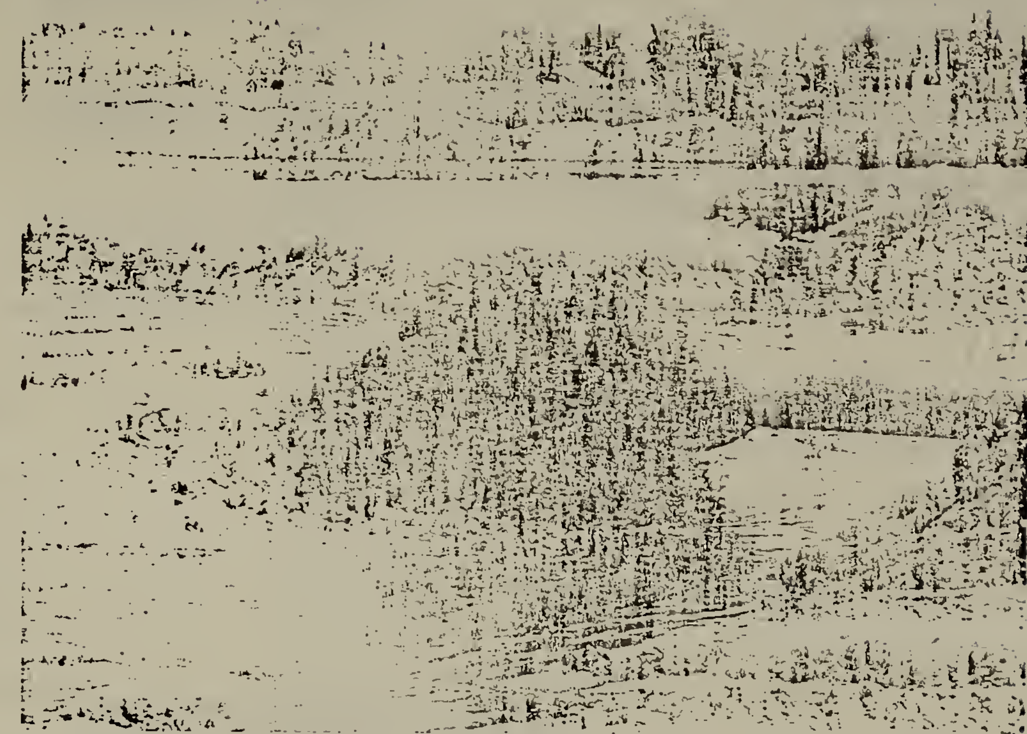

Illustration 31: Disposal of dredged material

## Activity Acceptability Table

This table indicates in which Resource Area dredge material disposal is or is not likely to be able to be conditioned to meet the performance standards set forth in the Regulations.

| Resource Area | Acceptability |
|---|---|
| Land Under the Ocean Section 25 | likely to be conditioned* |
| Designated Port Areas Section 26 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Coastal Beaches Section 27 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Coastal Dunes Section 28 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Barrier Beaches Section 29 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Coastal Banks Section 30 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Rocky Intertidal Shores Section 31 | likely to be conditioned* — (clean dredged material only) see section on fill. |
| Salt Marshes Section 32 | not likely to be acceptable — Sec. 32(3) states that no portion of a salt marsh may be destroyed. |
| Land Under Salt Ponds Section 33 | not likely to be acceptable — disposal will have an adverse effect on marine fisheries habitat which is not permitted under Sec. 33(3). |
| Land Containing Shellfish Section 34 | not likely to be acceptable in a DMF mapped shellfish area Disposal will adversely affect shellfish productivity by altering elevation which is not permitted under Sec. 34(4)(b). Can be conditioned in non-DMF mapped shellfish areas — unless otherwise prohibited in the Resource Area containing shellfish. See section on fill for conditions. |
| Fish Runs Section 35 | can be conditioned* — see section on fill |

*NOTE: Only clean dredged materials may be disposed in any site other than a designated disposal site

# DREDGED MATERIAL DISPOSAL
## Section 25 Land Under the Ocean

| Interest to be Protected | Adverse Effects to Interests | Conditions Required to Meet Performance Standards | Information Required to Develop the Actual Details to be Incorporated into an Order of Conditions |
|---|---|---|---|
| Storm damage prevention and flood control | ■ Disposal of dredged material may cause the shoaling of nearshore land under the ocean which will interrupt sediment transport processes, thereby affecting the volume and form of coastal beaches.<br><br>■ Disposal of clean dredged material on other than nearshore areas of land under the ocean is not likely to have an adverse effect on storm damage prevention or flood control. | 1. *Measure to meet performance standard of "no adverse effects" Sec. 25(5)*<br><br>■ Wave height at any point along the shoreline shall not increase by more than 10% by disposal of dredged material on nearshore areas of land under the ocean. | ■ Calculations showing existing and resulting wave heights. |
| Protection of marine fisheries | ■ Disposal of clean dredged material may cause the shoaling of nearshore land under the ocean which can create areas of stagnation.<br><br>■ Disposal of clean dredged material can alter the distribution of sediment grain size.<br><br>■ Disposal of clean dredged material may bury eel grass beds. | 1. *Measures to meet performance standard of "best available measures" Sec. 25(6)*<br><br>■ Disposal of spoil in discontinuous bands, interrupted at least every 250 ft. by 50 ft. breaks to provide for passage of water, nutrients and aquatic life. (These figures are guidelines only; the concept should be adjusted as necessary in the particular project).<br><br>■ Dredged material disposal on any portion of land under the ocean shall have a mean grain size distribution which does not differ from the existing land under the ocean sediment grain size by more than 50%.<br><br>■ Disposal of dredged material should avoid eel grass beds to the maximum extent possible. | ■ Description of water currents in the vicinity of proposed project.<br><br>■ Existing substrate conditions in the area to be dredged, including sediment composition, sediment grain size, and sediment density<br><br>■ Map of eel grass beds.<br><br>■ Alternative disposal locations to determine how to avoid eel grass beds to the maximum extent possible. |

Arsenic

| | |
|---|---|
| Dredging Regs: | <10 ppm. > 20 ppm |
| EPA Criteria: | As(III) 36 ppb/69 ppb * |

-can be methylated

-As (III) most toxic form. produced by biological reduction in seawater in freshwater - As(III) converted to As(V) in 30 days adsorbed on marine clays. phosphorite. Fe & Mn hydroxides. organic sulfur

-Uses - hardening of Lead and Copper alloys. paint pigments. cloth. glass and semiconductor manufacture. herbicides. wood preservative

-Typical Concentrations-

| | |
|---|---|
| lakes - | 0.1-35.6 ppb |
| Rhode Island rain - | 0.82 ppb |
| fresh water sediment - | 0.5 - 30 ppb |
| Puget Sound - | 2.9 - 10,000 ppb |
| Rhine Delta - | ND - 310 ppb |
| Rotterdam Harbor - | 30-110 ppm |
| seawater - | 2-3 ppb |
| avg. sediment - | 6-13 ppm |

-no known bioaccumulation

-uptake by Chondrus to 5 ppm, Laminaria 94ppm

-As (III) - toxic to invertebrates

-2.3 mg/l - reduced fish growth and survival: also significant effect on bottom fauna and plankton populations

-NED/COE suggested analytical method...gaseous hydride extraction with analysis utilizing Atomic Absorbtion Spectrophotometry (AA) +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents". Federal Register Vol. 50, No. 145, July 29. 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Cadmium

Dredging Regs: <5 ppm, >10 ppm
EPA Criteria: 9.3 ppb/43 ppb *

-occurs naturally as a sulfide salt

-similar behavior to zinc and lead

-readily released in organic decomposition, from settling particles

-20-45% in estuarine suspended solids

-incorporated to sediments under anoxic bottom conditions, aerobic release

-Produced by smelters, mining, electroplating, pigments, textiles, chemicals

-Typical Concentrations

| | |
|---|---|
| clean clay, shale - | 0.3-04 ppm |
| unpolluted estuary - | <1.0 ppm |
| polluted estuary - | 3.4 ppm |
| Rhine - | 5-45 ppm |
| Ems - | 1-3 ppm |
| Rotterdam - | 3-36 ppm |

-96hr $LC_{50}$ ($20^oC$)

| | |
|---|---|
| Pagurus longicarpus - | 180 ppb |
| Palaemonetes vulgaris - | 180 ppb |
| Crangon septemspinosa - | 80 ppb |

-fish muscle can concentrate by a factor of 1000

-Crassostrea virginica - exposed to 10 ppb from Apr - Aug accumulated 18 mg/kg wet wt

-bioavailability salinity and temperature dependent; strongly inhibited by presence of Zinc and/or organic compounds

NED/COE suggested analytical method...Acid Peroxide Digestion...AA +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents". Federal Register Vol. 50, No. 145, July 29, 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Chromium

Dredging Regs: <100 ppm, >300 ppm
EPA Criteria: Cr(VI) 50 ppb/1100 ppb *
Cr(III) no criteria available

-Cr(III) least common and least toxic, Cr(VIII) most toxic

-70-80% associated with crystal lattice, ~10% with organic solids
Sediments enriched by factor of 100

-toxicity varies with species, oxidation state, pH

-Typical Concentrations

| | |
|---|---|
| clean sediments - | 63-100 ppm |
| Rhine - | 1240 ppm |
| Rotterdam - | 190-870 ppm |
| avg. nearshore - | 100 ppm |
| crustal - | 80-200 ppm |
| seawater - | <1 ppb |
| Ems - | 120-180 ppm |
| Clyde Estuary - | 64 ppm (>204 m) |
| - | 624 ppm (in silt) |

-Bioconcentration: bethic algae-1600, phytoplankton-2300, zooplankton-1900, Mollusk-soft parts-440, fish muscle - 70

-Toxicity Values from Various Sources:

| | |
|---|---|
| Nereis virens -Prawns, Carcinus sp. | - 20 mg/l |
| Fundulus | - 200 mg/l |
| Coho Salmon | - 31.8 mg/l |

COE/NED suggested analytical method...Acid Peroxide Digestion...AA +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents". Federal Register Vol. 50, No. 145, July 29, 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Copper

Dredging Regs: <200, >400
EPA Criteria: -/2.9 ppb *
Additional: 0.1 x 96hr $LC_{50}$ during non-aerated biossay with senstive aquatic resident species

-adsorption by organic fraction of marine sediments 80-90% in crystal lattice...enriched in anoxic sediments

-Typical Concentrations -

| | |
|---|---|
| Avg. nearshore - | 48 ppm |
| Rhine - | 150-600 ppm |
| Ems - | 40-150 ppm |
| clean estuary - | 10 ppm |
| polluted estuary - | 37-225 ppm |
| detritus - | 2500 ppm |
| seawater - | 3 ppb |
| surface water - | 15 ppb |

-Generally salmonids sensitive, Atlantic Salmon avoid concentrations of 4 ppb

-Toxicity Values from Various Sources:

| | |
|---|---|
| *Nereis virens* - | 100 ppb |
| Oysters - | 100 ppb |
| kelp (inhibitation) - | 60 ppb |

-*Mya arenaria* - most sensitive marine microorganism in static bioassay (168 hours @ 30 ppt, 22°C)

| | |
|---|---|
| $<C_0$ | 25 ppb, 75 ppb |
| $<C_{50}$ | 35 ppb, 86 ppb |
| $<C_{100}$ | 50 ppb, 100 ppb |

-20 ppb fatal to *Mya arenaria* after several weeks

-*Fundulus heteroclitus* larvae - 9 day $LC_{50}$= 160 ppb

COE/NED suggested analytical method...Acid Peroxide Digestion...AA +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents". *Federal Register* Vol. 50, No. 145, July 29, 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

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Lead

Dredging Regs: <100,>200

EPA Criteria: 5.6 ppb/140 ppb *
Additional: 0.01 x 96hr $LC_{50}$ using receiving or comparable water as solvent and soluble lead measurements for most sensitive species

-removed from seawater by settling of particulates

-71% in crystal lattice

-Typical concentrations

| | |
|---|---|
| Mediterrean & Pacific - | 0.2-0.35 ppm |
| avg. nearshore - | 20 ppm |
| Rhine - | 330-950 ppm |
| Ems - | 91-106 ppm |
| Rotterdam - | 100-550 ppm |
| clean estuary - | 37 ppm |

-Toxicity related to pH, species, oxidative state, salinity, synergism

-threespine stickleback - chronic effects at 0.1-0.3 pm
lobster - death in lead lined tanks in 6-20 days
oyster - 48 hr. $LC_{50}$ 17330 ppb - adults, 2450 ppb - eggs

-Oyster exposed flowing waters of 25, 50, 100, 200 ppb after 39 days produced accumulation of 17, 35, 75, 200 ppm wet wt., respectively.

COE/NED suggested analytical procedure...Acid Peroxide Digestion...AA +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria: Availability of Documents". Federal Register Vol. 50, No. 145, July 29, 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Mercury

Dredging Regs: <0.5, >1.0 ppm
EPA Criteria: 0.025 ppb/2.1 ppb *

-Alkyl compounds most toxic to man in mg range

-bacterial methlylation makes any form potentially toxic, occurs at pH 5-9, aerobic or anaerobic

-

-higher portion in solution due to methiylation which occurs in top few cm. of sediments

-Typical Concentration -

| | |
|---|---|
| avg. nearshore - | 0.1-0.4 ppm |
| Rhine - | 5-25 ppm |
| Ems - | 1-3 ppm |
| seawater - | 0.03-02 ppb |
| river - | <0.1 ppb |

-20-90% in suspended solids

-Toxicity - -plants accumulate by surface adsorption
-fish concentration factor of >10,000 x

-high bioconcentration factors due to fast uptake but very slow release of mono & dimethylmercury

-biomagnification from bacteria to ciliates, and copepods from particulate

-1 ppb - threat to several marine organism

-highest bioavailability in sediments with low organic matter, sandy and neither highly oxidizing nor highly reducing.

-COE/NED suggested analytical procedure...Acid Permangnate Digestion...flameless (furnace) AA +

* from: U.S. Environmental Protection Agency, "Water Quality Criteria; Availability of Documents". Federal Register Vol. 50, No. 145, July 29, 1985. "Saltwater Aquatic Life" standards are defined as the four day average concentration and one hour average concentration, respectively, not to be exceeded more than once every three years on average. See source document for additional details.

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Nickel

Dredging Regs: <50, >100
EPA Criteria: 0.01 x 96hr $LC_{50}$ for fresh and salt water life

-may be released from deep sediments to surface sediments

-Fe-Mn pick up Ni to 1000 ppm

-Typical Concentrations -

| | |
|---|---|
| avg. nearshore - | 55 ppm |
| Rhine - | 47-103 ppm |
| clay - | 10-100 ppm |
| clean estuary - | 38 ppm |
| polluted estuary - | 50-60 ppm |
| seawater - | 5-7 ppb |
| freshwater (dissolved) | 3-86 ppb |
| freshwater (suspended) | 5-900 ppb |

-Toxicity - non-toxic to man

-wide variation of toxicity to aquatic life, influenced by species ph, synergism etc.

96hr $LC_{50}$ (20°C)

| | |
|---|---|
| oyster spat - | 1180 ppb |
| Mercenaria - | 310 ppb |
| adult stickleback - | 800 ppb |
| Acartia tonsa - | 625 ppb |

-toxic to plants at 500 ppb, freshwater crustacea reproduction 95 ppb fresh water life

COE/NED suggested analytical method...Acid Peroxide Digestion...AA +

+ from: Plumb, A.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples". Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Vanadium

Dredging Regs: <75, >125

-precipitates from freshwater to seawater, 0.001% entering estuary in freshwater remains in sewater, balance precipitates to sediments

-high absorption of ultraviolet light, used as insulator in electronics, 0.1% of steel, tool and die, alloys

-in fossil fuels as Vanadium Pentoxide; Venezelan Bunker "C" oil 300-400 ppm

-adsorbed by Fe & Mn

Typical Concentrations

| | |
|---|---|
| crustal - | 150 ppm |
| igneous rock - | 135 ppm |
| avg. nearshore - | 130 ppm |
| Severn Estuary - | 86 ppm |
| Shale - | 130 ppm |
| Limestone/Sandstone - | 20 ppm |
| North Atlantic Deep Sea - | 71 ppm |
| plankton - | 5 ppb |
| clay minerals - | 100-200 ppm |
| crustacea - | 0.4 ppb |
| fish - | 0.14 ppb |

-sediment enrichment factor 3-5x

-common constituant of fly-ash

-testing no longer required in Massachusetts as it does not appear to bioaccumulate (95-98% excreted)